THE

MAKING OF THE BODY

A Children's Book on Anatomy and Physiology

FOR SCHOOL AND HOME USE

BY

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OF WHITECHAPEL

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PREFACE

THE house we live in should, I suppose, be more interesting to us than any other structure, and every one might be expected to have some knowledge of the structure, mechanism, and functions of the body which he inhabits. In my experience, however, gathered in various spheres of life—as a doctor, as a sanitarian, as a lecturer, and as one cognisant of the modes of living and of thought, in various parts of the kingdom, and among many classes—I have found both among rich and poor a general, profound, and disastrous ignorance of nearly all that relates to the construction and the working of the body in health and disease. Even our instructors in the press show habitually the most appalling ignorance of elementary facts. A week or two ago I made a small collection of cuttings from the newspapers which undertook, on the occasion of the operation which Mr. Gladstone underwent for cataract, to give to their readers some idea of the structure of the eye and the nature of the operation. One leading paper gravely explained that he had had a film scraped from the cornea; another described an imaginary dispersion of opaque humours. On the whole, it was clear that not one writer in twenty had any conception of the structure of the eye, or was aware that the operation consisted in extraction of the lens, which had become opaque, through an incision made in the cornea. Nor is this merely a matter of curious observation. It is this absence of the preliminary study of the structure and functions of the body in health and disease, which places the mass of our population at the mercy of the whole herd of pill-vendors, bonesetters, and fraudulent quacks, who flourish now in thousands among us, whose vile practices do much to deteriorate the health of the people, and who annually rob them (especially the poorest) of a vast sum of money. It is a present popular belief that disease comes by Providence and goes by pills. The fact is that disease comes mainly by ignorance of the structure and functions of the body, neglect of the laws of health, and failure to understand how the body is kept in health; how each part of it is constructed, what are its needs, and how its working parts can be maintained in good order.

There are other reasons why I am glad to preface this book with a few words of approval and recommendation. I applaud its object, and I commend its method. In the work of the National Health Society, we have found that the greatest

obstacle to the improvement of the general standard of health is the profound ignorance of a large proportion of the people of all that appertains to their personal physique. In dealing with sanitary legislation, we are met everywhere with the same difficulty. It is of little use talking of the value of fresh air, of the selection of nourishing economical dietaries, or of the virtues of cleanliness, to those who are ignorant of the nature of breathing, and of how respiration and oxidation are carried on, or of the parts, processes, and functions of digestion, or of the structure and uses of the skin. To talk of blood-poisoning to those who know nothing of the blood, and of nervous exhaustion to those to whom brain and nerves alike are empty words, conveying no concrete image, is very largely a waste of time.

This book, then, has before it a large sphere of usefulness in the schoolroom, in the home, and for reading classes. Nor need the elder people despise it because it is written in carefully chosen words of great simplicity, and because it aims at a vivid picturesque diction which habitually resorts to the imagery of common life.

This book appears to me to be valuable in many ways. It has an evident value, first, as mere knowledge—an acquisition which cannot be overestimated ; it will, I think, be found delightful, in the next place, as a fairy tale which is true, a brilliant and attractive introduction to a new wonderland which lies beyond the realm of fiction, and here I may venture to praise it as being imaginative in diction and accurate in fact. I do not think that any scientific professor could have succeeded in freeing his mind so thoroughly from the technical phraseology, and in bringing to its lessons so much of fresh and sympathetic suggestion.

Whoever reads the book will rise from its perusal richer in new knowledge, and inspired with a sense of the relation of self to the great outer universe, which is at once impressive and reverential. I should wish to see it in the hands of every parent, of every teacher, of every journalist, and of every child in the kingdom. Its perusal has been to me a source of vivid pleasure, not unmingled with instruction ; and if this little book receives that wide circulation, which may, I think, be predicted and hoped for it, it will, I am sure, tend to add in no small degree to the healthfulness and happiness of this and of the succeeding generation.

ERNEST HART, D.C.L.,

Chairman of the National Health Society,
Editor of the "British Medical Journal."

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TO TEACHERS

"Nature, the dear old Nurse,
Took the child upon her knee,
Saying, Here is a story book
Thy father has written for thee."—LONGFELLOW.

"You are not guilty because you are ignorant; but you are guilty when you resign yourselves to ignorance."—MAZZINI.

ANY one who lives among the poor must be struck with sadness by the fact that they are stunted in body, and often handicapped in life by their physical weaknesses. This condition is not caused so much by poverty as by ignorance. Wishing to help, I began to speak of sanitary rules and hygienic laws, but I found that even such statements were not accepted unaccompanied by the democratic "Why?" I accordingly started physiology lessons in the school, and gave talks about simple anatomy to the mothers at their "Meetings."

Science is great enough to attract the humblest human minds, and so interesting did my simple explanations of how we are made become, that the children voluntarily stayed in after school hours, and ignorant women asked questions, and cared to understand the answers. One naturally wants to give to many what a few have enjoyed or been helped by, and thus this little book has been written. Let me say at once that it is not intended for any but the most ignorant—for the childish minds, whether they are lodged in young or old skulls. I had written many more simple illustrations, but the exigencies of school reading-book requirements have obliged me to cut them out.

The usefulness of the book, however, so largely depends on how it is taught, that I venture to write a few suggestions to the many who, as teachers, will, I hope, allow me to count them as my friendly fellow-workers.

Chapters I., II., and III. are intended to make the pupils think of, and so to become interested in, their own bodies—in what they do and do not do. Country children will not be so familiar with locomotives as town children, but all have, I suppose, seen some sort of machine and wondered at it. These chapters may be objected to on the ground that they are hardly physiology or anatomy; but they serve as a thought foundation on which to build the structure of fact that follows, and as such I hope the teacher will teach them. The plan of this little book is, first, to make the children think about their bodies; second, to teach them what is absolutely necessary concerning the skin, bones, muscles, the brain, and the nerves, to enable them to understand the functions of the organs. Then my effort has been to follow the food, the drink, and the air as they journey towards their goal—assimilation. After that I speak of the legs and arms, and then of those marvellous organs by which we hear, see, smell,

and speak. The book has been differently arranged to many of its kind in the hope that the idea of the air, the food, the blood, sounds, smells, and light taking journeys might appeal to the fancies of children, who ever delight in movement.

Chapter IV. So much entirely depends on the age of the children whether they are taught the proper anatomical names or only my English versions of them. Should the children be troubled by the difficult words, I should suggest omitting them, and for this purpose all the scientific terms have been put in parentheses and italics, so that in reading they may be entirely skipped. In all cases, however, where the names are not likely to create a distaste for the subject, it would be well to press the pupils to master them. After each lesson is read, it is suggested that the teacher should first get from the children what ideas they have obtained from the reading, and then correct them, instead of reiterating the lesson in the usual way. I have been amazed after reading these chapters, as I have done in the course of writing this book, to groups of girls or semi-educated people, to find the erroneous impressions that the simplest statements have given. Words are but symbols, and as such often misunderstood; but as it is the facts and not their word clothing that we wish to teach our pupils, it is of the first importance to discover what ideas the words have conveyed to them.

Chapter V. This lesson is dull, and will have to be enlivened by the teacher.

Chapter VI. If the reels on a string could be shown, it would help, and counting and naming them, as has been done with the vertebræ, would give interest.

Chapters VII., VIII. are both dull and difficult, but they must be mastered if the pupil is to be more than moderately interested in physiology.

Chapters IX., X., and XI. I have always found evoke interest. Elastic is easy to get, and the pupils can illustrate what they learn by the movements of their own limbs. If a class is being taken, it is well to let all the children do the exercises: it makes them feel a scientific interest in their own personality.

Chapters XII. and XIII. are hard, and may be taken as four lessons if necessary, for the bones and their positions should be accurately learned. If the children touch the parts of their heads and faces, it becomes easier.

Chapter XIV. is interesting if not easy. I have chatted about Japanese and Red Indians, to give the child mental breathing time between the outside and inside skull brain coverings.

Chapters XV., XVI., XVII., XVIII., XIX., XX., XXI., and XXII. have been written with extra care, but simple as I have tried to make them, there still remains to the teacher the still more difficult task of making them real to the children. These are chapters which must not be confused: the pupil must definitely learn the difference between nerve fibres and nerve cells, between reflex action and the ganglionic system. Physi-

ologists will laugh, if not jeer, at Miss Sympathetic, but I believe teachers will find her helpful; and if not, if they will tell me, I will abolish her in the next edition.

With Chapter XXIII. we start on the journey of the food. It seems strange to have omitted all mention of the various chemical changes that occur to food as it travels, but I have purposely refrained from referring to anything which I could not explain fully, even if elementarily; and the chemistry of nutrition is in itself a subject for another book. We follow the food over the tongue, Chapters XXIV., XXV., past the teeth—Chapters XXVI. to XXXII.—down the pharynx and through the stomach and into the intestines before we leave it. These chapters I have always found create much interest, especially if the earlier stages of the journey are recalled before a fresh start is made.

Chapters XXXIII., XXXIV., and XXXV. are less easy but not less important. It would have been simpler if we could have re-named the chyle and called it lymph before we followed it into a lymphatic vessel; but as that could not be done, I have followed it as chyle until it was safe in a lymphatic trunk, and then more rapidly sketched the travels of the other lymph materials.

In Chapters XXXVI. and XXXVII. I have told of some of the evils of alcohol drinking, a matter on which the teacher can usefully enlarge, if his or her experience tallies with mine, that it is the erroneous idea that strong drink "keeps the cold out," or that "beer gives strength," that starts and keeps many in drinking habits.

One of the most fruitful sources of class discontent and antagonism is the idea that the rich only can get the food necessary to produce strength. What a crop of social evils are growing from the one root of ignorance of food values; but as the subject is too vast to be included in this book, I have been obliged to be content with chatting and telling anecdotes, which the teacher, however, can confirm as being based on scientific fact, which can be explained should time or the capacity of the pupils allow it.

In Chapters XXXVIII., XXXIX., and XL. we follow the air as it journeys. These chapters are easy, and if the epiglottis is not quite understood, an enlarged drawing of Fig. 64, on the blackboard, will make it plain. I have found that if the pupils breathe fast, or hold their breaths, it helps to illustrate this lesson.

Blood and its circulation is dealt with in Chapters XLI., XLII., XLIII., XLIV., and XLV. It will greatly aid if the teacher can get the children to understand and like the wood-cuts, but it may be found necessary to draw them even more rudimentarily on the blackboard. Fig. 69 we can hardly expect children to understand, but I have been so fearful that my simple explanations will make them fancy they "know all about physiology," that I have sometimes put in a more difficult illustration in order to excite admiration and provoke them to humility. The table of the stages of the blood's journeyings should,

perhaps, in most cases, be committed to memory. Few children could be expected to think accurately enough to think it all out.

Chapter XLVI. deals with the portal circulation, easy if the pupil has once mastered the law of circulation.

Chapters XLVII., XLVIII., XLIX., and L. are not difficult, but neither are they interesting. These might have been put among the other bone chapters, had I not thought that so many bones together might become a hindrance, if not a final barrier, to progress. The lesson can be made interesting by the pupils being allowed to feel or count each other's, or their own bones.

Chapter LI. always gives pleasure, and I hope my elder readers will forgive my childish examples.

Chapter LII., where an odour's wanderings are followed, is not wholly easy—the nose bones are so complicated; but shreds of paper twisted into approximate shapes can give an idea—to imaginative minds.

Chapter LIII. will be appreciated by those who master it. It will make it plainer if the pupil quite understands that Figs. 94, 95, and 96 are views of the back, the front, and the inside of the larynx respectively.

Chapters LIV., LV., and LVI. I enjoyed writing, and I enjoy teaching. The sound journey is not too long, and it is all so dainty and pretty. The children must be reminded of the diminutive size of this wonderful organ.

Chapters LVII., LVIII., LIX., and LX. are best taught with an eye model, but should this not be forthcoming, an onion is helpful, for its coats lie, like the eye coats, close together, and like them form the thing itself. If there is any view to be seen, the children might try a "topsy" for their amusement and edification. These chapters are long, but even now, as the teacher well knows, I have been obliged to omit much about the complicated structure of the beautiful instrument.

The right study of the healthy body is so often confused with that of disease that I have been most careful to avoid mention of ailments. It has seemed to me that childish minds had better learn only of the body in the beauty of its health. In certain cases I have, however, felt obliged to refer to accidents which, having caused interruptions to the normal regularity, have proved its very existence.

I send my little book out with fear, knowing how very far short it falls of what it might be; but if it starts in any one a wish to know more about their bodies, it will have done its work. I send it forth with hope too, for I remember my own sense of abundant joy when a similar book taught me something about the making of the body. I send it out too in the confidence (a confidence founded on my privilege of calling many teachers my friends) that those who use it will kindly tell me how I can make it more useful, and if it reaches a future edition, where I can make it more clear.

HENRIETTA O. BARNETT.

THE MAKING OF THE BODY

CHAPTER I

THE BODY AS A MACHINE

I SUPPOSE every one who reads this will have seen a steam-engine. Some of you who live in factory towns will perhaps know a good deal about machines; others will know little else than that they have seen the engines draw the trains. In many ways our bodies are like engines. I will tell you of five ways in which they resemble each other.

I. **The human body and the engine require food.**

II. **The human body and the engine throw off waste.**

III. **The human body and the engine have to be kept clean.**

IV. **The human body and the engine are preserved by use.**

V. **Each part of the human body and of the engine depends on some other part, without which it would be useless; and without it the whole would be useless, or very much less powerful.**

Now let us consider each of these five headings one by one.

I. **The human body and the engine both require food.**—Our food is to us what the fuel is to the engine. Neither the body nor the steam-engine can go on unless plenty of food or fuel is given to it. Without food we

should die, as the engine does if the stoker forgets to feed it. The engine wants coal, coke, oil, and water as its food; we want three sorts of food, *i.e.*—

Strength-giving food (*carbonaceous*),
Flesh-repairing food (*nitrogenous*),
Health-preserving food (*mineral*),

and plenty of air and water as well. More about this I will tell you in another chapter. Now we will pass on to—

II. **The human body and the engine both throw off waste.**—We have all seen the steam-engine puff off its clouds of steam, which roll away in beautiful wreaths and lovely shapes; and in the evening, when it is lit up by the fires beneath, it looks like an overhanging cloud of glory, leaving behind a trail of light, like a gentle memory. We have all seen this, and some of us have seen the stokers shovel out the clinkers, or fuel which has not been wholly burnt. Thus the engine throws off its waste. Human beings throw off their waste in different ways—by the perspiration of the skin, by the help of the kidneys and the liver, and by the breath. By various methods both machines and people alike must throw off their waste, or it poisons them and hinders progress.

III. **The human body and the engine both have to be kept clean.**—Did you ever see a dirty engine? One feels quite sorry about it. It works with such an effort; it wheezes and groans, jerks and splutters, and sometimes breaks itself in its effort to go on before it runs down altogether and stops dead. It is sad to see an engine spoiled by dirt, but sadder still to see the beautiful human body injured for want of washing. But it often is.

Bodies want washing inside and out. This can be done in various ways, but, on the whole, water is the best thing to wash with. Better than beer, spirits, or medicine for the inside; better than sand or oil for the outside. When we come to the chapter on the skin I will tell you why.

IV. **The human body and the engine are both preserved by use.**—"In disuse there is death" has said one of the wise ones, and it is true of both the machine and the human body. Mr. Darwin, in his great book, tells how all hogs, hundreds of years ago, used to have tusks, with which they bored and got their food; but when that animal was taken by man and put in a stye and fed, he had no further use for his tusks, and so in each generation of pigs the tusks got shorter and weaker, till gradually they disappeared altogether—by disuse they died.

And how soon the engine falls to pieces if it is not used! The iron corrodes, the screws get loose, the boiler becomes rusty, and after a long period of idleness the engine is found to be "all but unfit for use."

And now we come to the last of our five.

V. **Each part of the human body or the engine depends on some other part, without which it would be useless; and without it the whole would be either useless or less powerful.**—St. Paul, who wrote so much that is wise and deep, speaks of this scientific fact in one of his long letters—the one he wrote to the Corinthians (1 Cor. xii. 12). He says: "For as the body is one, and hath many members, and all the members of that one body, being many, are one body. . . . If the foot shall say, Because I am not the hand, I am not of the body; is it therefore not of the body? . . . But now are they many members, but one body. . . . And whether one member suffer, all the members suffer with it."

If you think, you will see how true this is. If your head aches, you feel ill; if your heart is diseased, though all your other organs may be quite well, yet you are ill, and will probably die of it. If your lung is stuffed up, all your body is kept air-hungry, and soon gets weak. This is also true of the engine. Each part depends upon the other; and thus it is necessary to keep the boiler clean, the wheels strong, the funnel straight, or one damaged part will cause injury to the whole.

Have you ever seen any delicate machine? I once went over the Mint at London, where the coins are made, or "struck," as it is called. It is very important that each coin should weigh exactly what it is said to weigh, and so every sovereign, and shilling, and sixpence, or threepenny-bit is put into the scales before it is sent out on its way in the world, to be paid in wages to some worker, or to buy "goodies" for some child.

The machine where the sovereign is weighed is most beautiful. It is so delicate that even changes in the wind or a shower of rain affect it, so it has to be kept under glass. Through a narrow hole in the glass case a sovereign is slipped in by another dainty machine. It stands for a moment on the scale; then if it is too heavy, even one hair's weight too heavy, it is tipped off on one side, and goes back again to the fire to be melted down and made all over again. If it is too light, it gets tipped off on the other side. If it is just right, it passes on to a bowl to join the other sovereigns that are exact and fair, and is then all ready for use. It is a wonderful machine, every part perfect, every part clean, every part doing its own work and depending on the other parts.

But wonderful as it is, it is not so wonderful as the human body. The mechanism by which the heavy coin is turned on one side, the light coin sent to another, and the right one pushed forward, is not so delicate or so beautiful as the mechanism of the eye, by which we see colours, tolerate strong light, or get used to dull atmosphere.

All the machinery that ever was made is not so complicated as the arrangement in our ears by which we hear sounds, or the contrivance to carry those sounds up into our brains, by the aid of which we know whether the sound we hear is baby's cry, if we have left it alone too long, or the clear song of the blackbird, who is singing in his own language of his happiness.

CHAPTER II

THE BODY THE ONLY MACHINE WHICH GROWS

IN "Uncle Tom's Cabin" there is a conversation between Topsy and Miss Ophelia which those of you who have read the book will be sure to remember.

"Do you know who made you?" asked the lady of the little negro child.

"Nobody as I knows on," said the child, with a short laugh; and presently she added, "I spect I grow'd. Don't think nobody ever made me."

Good Miss Ophelia was pained that the child should not know about the great God; but in Topsy's last answer there is truth. In one sense "nobody never did make us—we grow'd." Within us is put the power of growing, and to each of us is given the choice of growing rightly or wrongly, strongly or feebly, according to how we acted and treated our bodies; but none of us were ever made in the sense that a machine is made, that is turned out and finished with nothing more to be done to it.

No; herein is the difference between the steam-engine and the body. We have seen how both require food, both throw off waste, both have power or force to move, both have to be kept clean, and both need use to keep them healthy; but the human body differs from the machine in this great matter, that the body grows.

Every one knows how the little one grows. There is the dear tiny baby with the sweet clinging fingers, and twenty years afterwards here it is the strong man with the broad shoulders and the horny hands, or the tall woman with her bright, active ways and kind, helpful thoughts.

"How he, or she, does grow!" has been said of all of you by some friend who has not seen you for a while, and you all know by that is meant that you have become bigger, or stronger, or stouter. But this wonderful body of ours has another way of growing. When we are quite grown up it still goes on growing, though we do

not become bigger. All the growing power is then used by the body in repairing itself.

When the boiler of a steam-engine is worn out, the men have to make another in the big, noisy workshop, take it to the engine, and fit it in. If a screw gets loose, or broken, the engine has to be stopped; the men come and tighten it up, or put in a new one. And you have all noticed, when you have been on a railway journey, that at the large stations two men go round the train and look to the wheels. One puts grease into the wheel-boxes, and the other hits the wheels to find out by the sound if they have any little crack or flaw in them, or if they have got hot by going quickly round.

All this is done for the engine because, clever as the engine-makers are, they cannot find out a way of making the engine mend or repair itself; but to our bodies is given the power of mending and repairing themselves.

It has been said that human bodies entirely re-make themselves every seven years. I do not think that we can be sure of the truth of this statement so far as the time of seven years is concerned, but otherwise it is correct. Our bodies in certain ways re-make themselves, not in all ways. We have all seen people who have had a leg or an arm cut off. The limb once removed does not grow again. In some animals it does. If the lobster lose its claw it gradually grows again, and once more in its life it has got two claws; but this great power is not given to the human body.

Neither can our bodies repair themselves if they have been wrongfully damaged. They can keep themselves in good order, and repair that which gets naturally worn away; but if, for example, the stomach is injured by too much strong drink, it cannot again become quite so healthy and vigorous as it was before the evil habit was begun, though it will get much better by degrees if alcohol is avoided. If the little holes in the lungs get stuffed up and become hard and solid, instead of soft and porous, they cannot repair themselves and become "as good as new."

No; in our bodies, as across other things, are written

two words which carry sadness to those who understand them—the "irreparable past," and they mean that what is done cannot be undone. And yet into our hands is given the future, however badly we have used the past; and it is also true to say of our bodies, as of other things, "It is never too late to mend." But mended things are not so nice as whole ones, are they? Neither shoes, nor tea-cups, nor chairs, nor anything else that one can think of; and this is also true of human bodies.

Thus it would be better so to treat our bodies that they never get injured beyond what they themselves can repair. They can manage to do all the repair necessary for fair, honest usage, but they cannot mend themselves if they are injured by accident, or man's disobedience to the golden rules of health; rules which have to do with food, heat, cleanliness, light, exercise, rest, and perhaps the most important, if the most difficult, self-control.

CHAPTER III

WHAT IS GROWING?

In the last chapter growing was spoken of. What is growing?

"Growing! Why, growing is getting bigger, of course," I seem to hear the eager but unthinking child answer. Yes and no. Getting bigger or fatter is the result of growing, but that is hardly what growing itself is. What is growing? One wise man I put the question to replied that—

> "**Growing is the assimilation of certain portions of the environment by the animal or plant that grows.**"

In the Dictionary you will find it is stated that "to grow" is "to produce, to raise, to become enlarged, to advance towards a state, to extend, to improve, to become.

Both these definitions sound difficult, and what some of you would call "dry"; but nothing is dry if once it is understood, so let us try to understand what is meant by them.

You will remember that in the last chapter two sorts of growing were mentioned—the growth from small to large, and the growth of repair or mending. In order to make it easier we will now only consider the first sort of growth, *i.e.* from small to large. If a thing is to get bigger something must be added to it. This every one will see. You have a bit of beef; you want it to be bigger; you tell the butcher to add another piece of meat to it. You have a length of calico; you want it longer, so you take another length and join them together. You are making a rice pudding; some one runs in and says—

"More people are coming to dinner."

So you add more rice and more milk, and the result is that the pudding has grown larger.

Now read the wise man's answer to my question again —"Growing is the assimilation of certain portions of the environment by the animal that grows."

The new rice and milk that you added to the pudding were mixed up with the other rice and milk that were already there, the fresh materials became part of the old pudding, and it—the same pudding—became larger.

Whatever is around us, and not in us, is our environment. Before the new rice and milk were added to the already mixed pudding they were the environment of the pudding—they were outside and around the pudding; but when they were added to it they became part of it.

Human bodies are in the world; all around them is air and vegetables, beasts and fowls. These things surround them; they are "certain portions of their environment." In order to grow they must take them into themselves. Human bodies, already consisting of certain things, must take into themselves, or assimilate, certain other things. In some ways like the pudding which, already consisting of certain things, had to have more milk and more rice taken to it and mixed up with it, so that it should become larger.

There are various things that bodies must take in, and various ways of taking them in; and there are all sorts of marvellous contrivances in human bodies by which they take in and make part of themselves certain portions of the outside world. This is what assimilation means. It is adding and mixing, and yet something more than adding and mixing.

We imagined the meat and the calico made bigger by the addition of more meat and more calico. These were added together, but not mixed together.

We imagined the pudding had become larger because more rice and more milk were added and mixed: but the human body has to do more than add or mix; it has to take certain portions of the things that surround it, and add them, and mix them, and also assimilate them, or work upon them, until they leave off being themselves and become part of the body itself. The word "assimilate" comes from the Latin word *similis*, like; and if the human body will grow, it has to take a cabbage, or some meat, and first make it similar or like to itself, and then add it to itself, or assimilate it.

While people are growing it is very important that they should hold themselves straight.

It is told of one great Emperor that he felt this so strongly that he commanded that every young man among his people should be drilled, and taught to hold himself upright. He was often rough in his manners, and one day, when he was reviewing his soldiers, he saw among them one with stooping shoulders and bent head. The lad was a clever fellow and generally respected, only he held his body badly. "Bring that man here," he commanded, and the slouching fellow stood before his sovereign, himself tall, strong, and erect. "Why do you stoop?" asked the Emperor. "I can't help it, please your majesty," returned the man. "But it does not please my majesty to see you stoop," was the reply; "but it shall please it to punish you for it. Degrade him," he ordered, turning to the officer.

Was not that a hard punishment for a bent back? but it need not be told that it served as an example,

and that the other youths took more care to hold themselves properly, and thereby their health, as well as the appearance of the army, was improved.

Much more about the wonders of the human body you will hear, with, I trust, reverence and admiration, as you read this little book and as you learn of the methods by which certain portions of our environment are taken in and become part of the human body. Of these things, shortly, are

Air, Food, Water.

CHAPTER IV

THE JOURNEY OF A PIN WITH EYES

THE SKIN

LOOK at the skin on your hands.

"Grubby hands," I seem to hear the teacher say, perhaps in a tone of reproach; but just now we will forget the grubbiness and think only of the skin; though presently you shall hear why every one is right who speaks reproachfully of the skin being allowed to be dirty.

The skin you have been looking at is the **Upper Skin** (*epidermis*). Now look at the picture.

It is a bit of skin magnified twenty diameters, and then drawn. Suppose you took a pin and ran it into your finger. If the pin had eyes, it would see what this picture shows. The picture is about three inches deep, but you would not need to run the pin three inches into you. The picture is magnified, so the pin would see all that is in this picture if you only ran it into you a little bit, like this —.

The pin would first go through the upper skin (*epidermis*), marked *a* and *b* in the picture. This would hurt, because it would prick the endings of the nerves, which you will learn about in another lesson, but it would not cause any blood to flow. In the black layer,

marked *b*, the pin would go through spaces called cells, which contain colouring matter. It is not really black except in negroes, but in everybody these spaces contain some colour, more or less, and this is what makes people dark or fair. A negro is black, an American Indian copper-coloured, a Chinese yellow, because of the colour

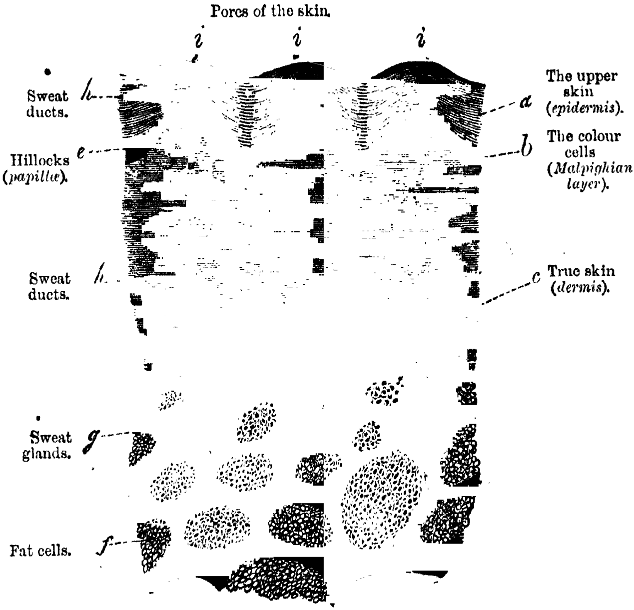


FIG. 1.—SOME OF THE THINGS THE PIN WOULD SEE. VERTICAL SECTION OF THE SKIN. MAGNIFIED 20 DIAMETERS.

a. Epidermis; *b.* Malpighian layer; *e.* Papillæ; *f.* Fat cells; *g.* Sweat glands; *h.* Sweat ducts; *i.* Pores.

in these cells, and if we could take it all away, we should be able to turn any man, no matter what colour he is now, into a white man.

"How thick is the upper skin (*epidermis*)?" you may ask. The answer would depend on what part of the body

you had chosen to put the pin in. In the palms of the hands, where you have been looking at the skin, it is sometimes as thick as $\frac{1}{20}$th of an inch; but in other parts, where the skin feels very soft, it is only about $\frac{1}{200}$th of an inch.

If our imaginary travelling pin once got through the colour cells, it would reach the deeper layer, which is called the **True Skin** (*dermis*) and marked *c* in the picture. Here it would meet with more nerves and blood-vessels. If broken or pricked the blood-vessels would let out the blood, so then both pain would be felt and blood would flow.

The nerves and blood-vessels are twined in and about the true skin (*dermis*), which itself consists of tissues, or flesh that is elastic and yet clings together.

If you look carefully at Fig. 1, you will see that the top of the colour-holding cells (*Malpighian layer*), marked *b* in the picture, is flat, while the bottom is jagged, allowing the true skin (*dermis*) to run up into it, while bits of the colour-holding cells branch downward in among the true skin (*dermis*). This uneven arrangement enables the nerves and blood-vessels to go up nearer to the upper skin (*epidermis*), and at the same time gives more room for the cells that hold the colour than if they were narrow and straight. These little mounds or **hillocks** in the true skin (*dermis*) are called **papillæ**.

Still following the pin, we must imagine it going through the dermis till it reaches the land of fat. Here it will meet with cells or little cavities filled with fat or oily substance. In fat people these cells are full and swollen; in thin people they are empty and much smaller.

Fat cells are very useful; they are like a thick woollen garment, keeping the body warm. We all know how much colder thin people feel than fat people do. One of the reasons of this is because the fat cells of thin people being empty, the heat of the body gets out, and so they feel cold. Do you know what is meant by

The pores of the skin?

Once more turn to Fig. 1. You will see three lines going down it marked *h*. Let us follow them. They are a little twisted as they go through the first layer of the upper skin (*epidermis*), *a;* quite straight as they pass between the colour cells (*Malpighian layer*), *b;* wavy in the true skin (*dermis*) *c;* and all coiled up as they lie between the fat cells. These lines are meant to represent

The pipes to carry sweat (*sweat ducts*).
The coils to collect sweat (*sweat glands*).

The openings of the ducts on the top of the epidermis, marked *i i i* in the picture, are the pores of the skin which eject sweat.

Around each of these little coils or sweat glands are numberless blood-vessels. As the blood hurries along through these vessels it is the duty of the sweat glands to take from it a fluid that is called sweat. Then begins the duties of the sweat ducts or pipes. They have to pass the sweat which the glands collect upwards, and push it out of the pores.

You have all seen perspiration standing in little drops on the face of a man who is hard at work, or who has been running fast. The tiny drops come out of the pores of the skin, which are the mouths of the sweat ducts, and every day as much as two pints of perspiration should pass through these pores. If dirt is allowed to be on the skin, the sweat cannot get out; it has to remain inside; and as it consists of something which the body wants to get rid of, it injures and weakens the body. Now you see one reason why the elder or wiser folk look reproachfully when hands are grubby or bodies left untubbed.

Sweat glands, sweat ducts, and **pores of the skin** are all over the human body, but there are not so many of them in some parts as in others. The legs and back have about 600 to every square inch, but in the hands and feet there are more, the palms of the hands having as many as 2500 in the square inch.

If all these little perspiration pipes which are over the

body were fastened together, they would reach for more than thirty miles. Just think of thirty miles of pipes to keep clean!

Yes, but that is not given us to do; all that is asked of us is to keep the skin clean, so that their little mouths may not be choked by dirt. If the mouths of the sweat ducts are closed, the little glands are hindered from doing their proper work, for then the sweat cannot get out, and so the blood has to be still burdened with the impurities which it was the duty of the sweat glands to collect, and the sweat ducts to convey to the skin, to be got rid of by their pores or little mouths.

CHAPTER V

WHAT ARE BONES?

Do you think this picture of a skeleton is ugly or pretty? Some of you will think one thing, some another. It certainly looks ugly, but when you know more about it you will know it really is beautiful—beautiful with the beauty of fitness, order, and use.

If you study it carefully you will see some of the bones that are in the human body, of which altogether there are 249. You will not be able to learn many of their names, but of the most important you must know something.

In this and the next chapter we will talk only about the bones of the body or trunk; but before we do this, you must learn about bone itself, and what it is. Bone is composed of—

I. **Animal matter** (*organic*).

II. **Mineral matter** (*earthy*).

To every one part of animal matter there are about two parts of mineral matter; or, to put it accurately in figures, bone is composed of—

Animal matter, or organic	33
Mineral matter, or earthy	67
	100

Both substances are well mixed together, though it is not difficult to separate them. You have perhaps seen the jelly that is made by long boiling of beef bones or calves' feet. That is the animal matter when it is divided from the mineral by boiling.

The bones of an old person are different from those of a child. A baby or young child has little mineral matter in its bones.

One day, when I was walking in Whitechapel, I saw an old lady come out of the door carrying a baby. She was thin and shrivelled, but the baby was a bonnie little lass, and she held it with all kind care and tender thought, cooing and talking baby language to it as she went. But she did not get far; for her foot slipped on a bit of orange peel, and she fell flat, the baby falling out of her poor slim arms and rolling a few yards off.

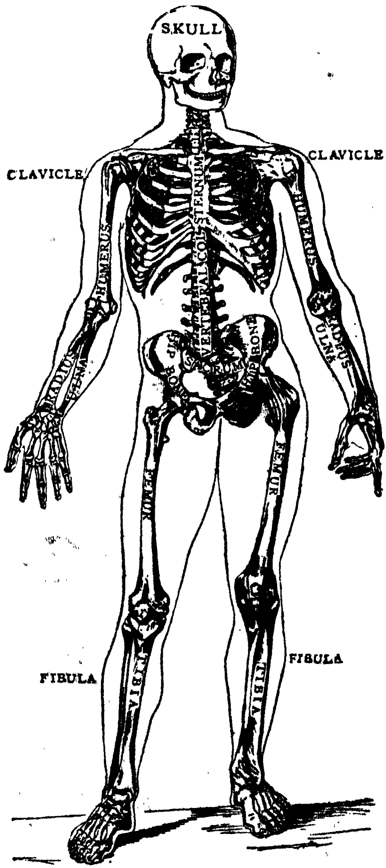


FIG. 2.—THE BONES WITHIN THE BODY.—SKELETON.

I rushed to pick up the baby, as one naturally does go first to the help of the most helpless; but though it roared with all its power, we soon found that no bones were broken. Its little bones were still soft, and had not been hardened by the earthy or mineral matter.

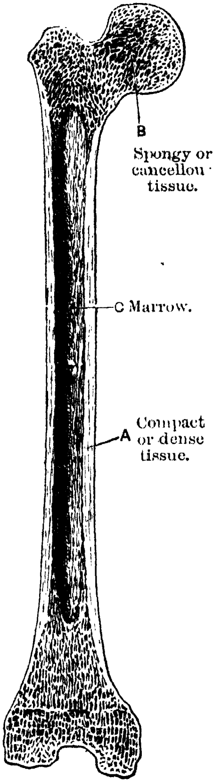


FIG. 3.—A HOLLOW BONE. THE FEMUR OR BIG LEG BONE, SHOWING TWO SORTS OF TISSUES AND THE MARROW.

But the poor slim old body lay and moaned, and only after we had got her to her home did we learn that the bone in her left arm was broken, and that the fingers in her right hand were damaged and crushed. The bone she broke is called the Radius. You will see it marked in the skeleton. Her bones were brittle, because during her long life much earthy mineral matter had been added to them; and also because, as she was so thin, the little cells containing the fat, about which you learnt in the chapter on the skin, were all but empty, and so the bone had no warm covering of fat to protect it from the hard flag pavement.

All bones are made up of two sorts of tissues—

Compact (*dense*) **tissue.**
Spongy tissue (*cancellous*).

The hard, ivory sort of substance that every one has seen when they look at the bones in the butchers' shops is called **compact** (*dense*) **tissue.** The softer, looser sort of substance that **is formed at** the head of long bones is called **spongy tissue** (*cancellous*).

Do you not know how easy it is to bite through the head of the chicken leg-bone, while the teeth will make

little or no impression if they are tried in the middle of the same bone? That is because the head of that bone is made of **spongy tissue**, with a very narrow rim, if any, of **compact tissue.**

There are three sorts of bones in the human body—

1. **Hollow Bones, such as those of the leg.**
2. **Flat Bones, such as those on the top of the skull.**
3. **Irregular Bones, such as the back-bone.**

I will now tell you what distinguishes each of these sorts of bones—

1. Hollow Bones

have (1) an outer coat of **compact** or **dense tissue.** (2) Their heads are filled with spongy tissue. (3) Their hollow parts contain marrow. On the opposite page is a picture of a hollow bone; it is the big leg-bone (*femur*).

The compact or **dense** tissue is marked *A*. The spongy tissue (*cancellous*) is marked *B*. But I have not yet told you about the substance marked *C*. That is **the marrow.** Marrow consists of blood-vessels and cells full of fat. It is considered very nice to eat.

2. Flat Bones.

Here is a picture of one. Flat bones consist of a layer of the spongy (*cancellous*) tissue, which, you will remember, is the soft and porous substance between two layers of the compact (*dense*) tissue, which is the hard, ivory-like substance. A shoulder of mutton will give a good example of this sort of bone.

FIG. 4.—A FLAT BONE. SHOULDER BONE FROM BEHIND.

3. Irregular Bones

Both the irregular and the short bones are composed of spongy (*cancellous*) tissue, surrounded by a covering of compact (*dense*) tissue, and this varies in thickness according to the work the bone has to do, or the place it occupies.

The spongy bone (*cancellous*) looks something like a sponge. It has little holes all over it, and in these holes there is a kind of marrow, or collection of fat cells and

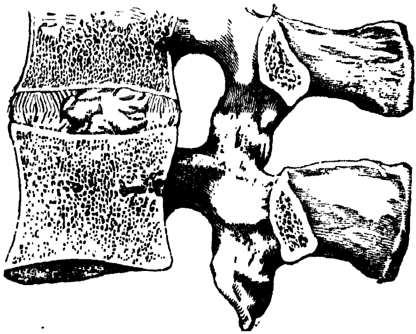


FIG. 5.—AN IRREGULAR BONE. PART OF THE BACK-BONE. SECTION THROUGH LUMBAR VERTEBRÆ.

blood-vessels. You will have seen it if you have cut or broken the bone of a mutton-chop (*irregular bone*), or of a shoulder of mutton (*flat bone*). It is a sort of fluid, reddish in colour, and not so rich as marrow.

One of the reasons why the old lady who slipped on the orange-peel broke her bones was because she was so thin. Not only were the fat cells in her skin empty, but the fat cells in her bone tissues were less full, and so her bones were not, as it were, filled in.

CHAPTER VI

THE BACK-BONE—THE VERTEBRAL COLUMN

Now, children, you must be ready to work hard over this and the next chapter, for they will be difficult. First turn to the picture of the skeleton on page 15. Look at it well. You have got to learn to-day about the bone that runs up the middle of the body. It has three names—

The back-bone or spine (*vertebral column*). On page 22 is a picture of it seen from the side.

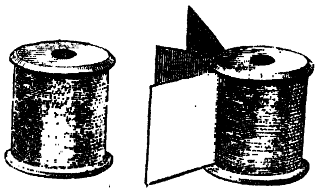


Fig. 6.—Reels of Cotton illustrating Vertebræ and their Processes.

Can you imagine a number, say twenty-four, of reels of cotton? The reel will be this sort of shape. From one side of each reel we will suppose that a piece of wood projects. Now let us add to it two more side-pieces of wood, thus, and we shall have a reel with three little wooden flaps or wings sticking out of it. Let us fancy that we thread these queer-shaped reels on a bit of string, standing each reel on the top of the other reels. If we keep the string fairly tight we shall be able to bend what will now be a sort of stick made of reels to and fro, and this will be a rough model of the back-bone of the human body.

The back-bone (*vertebral column*).

The spine is made of a number of bones, each standing on the other, as we imagined the reels doing. Each of these bones is called a bending bone (*vertebra*).

The part marked *S* in the picture is the body of the vertebra; the part marked *M* is the hole or channel through which the spinal cord goes, just as we imagined the string going through the cotton-reels. The parts

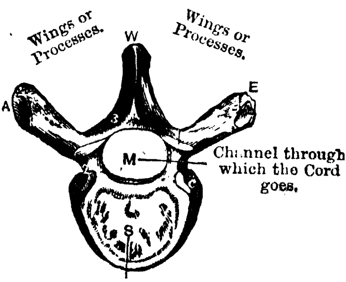


FIG. 7.—A BENDING BONE (VERTEBRÆ).

marked *A*, *W*, *E*, are the three wings (*processes*). Now turn again to the picture of the spine, and you will see how the round, smooth parts, *i.e.* *S*, of each turning bone (*vertebra*) lie inside the body, the pointed wings or processes being placed outside.

The spine often gets out of order.

I remember, when I was hardly older than any of you, seeing a little boy who was always lying down taken out every day for an airing in a long wheeled couch. We used to run about with our hoops or enjoy a good battle with the wind—the strong sea-wind which made the waves leap and dance, and brought the roses to our cheeks; but the little boy was always kept

lying down, and wheeled only into warm and sunny corners.

"He can't half enjoy Brighton," we said to our nurse. "What is the matter with him?"

"His spine is bad," said nurse, and bade us be sorry for him, and grateful that God had made us straight.

We did not know what she meant by "bad" then, but now I know; and you will understand when I tell

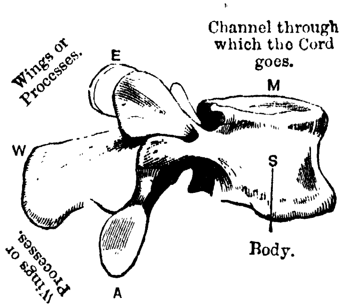


FIG. 8.—SIDE VIEW OF A BENDING BONE (VERTEBRA).

you that the vertebræ, or reels of cotton, as we have likened them to, were each pressing hard upon the other, and that the little boy had to lie down so that his weight should fall on his couch. If he had stood up straight the muscles which hold the back-bone upright would have become weary, and the long row of reels would have curved either to one side, to the other, or out behind. You will have seen humphy-backed boys. Poor little lads, they have grown crooked, because, when their backs first became "bad," they did not lie down and rest the spine and its bones from all movement.

Let us count the turning bones or vertebræ. There are—

7 to the first line marked *A*—**these belong to the neck.**
12 to the second line marked *S*—**these belong to the back.**
5 to the third line marked *M*—**these belong to the loins.**
The 5 to the line marked *U* are really all joined together, and so may be counted as one; and then there come
4 little ones to the line marked *E*.
33 in all.

These last are the beginning of the tail in other animals.

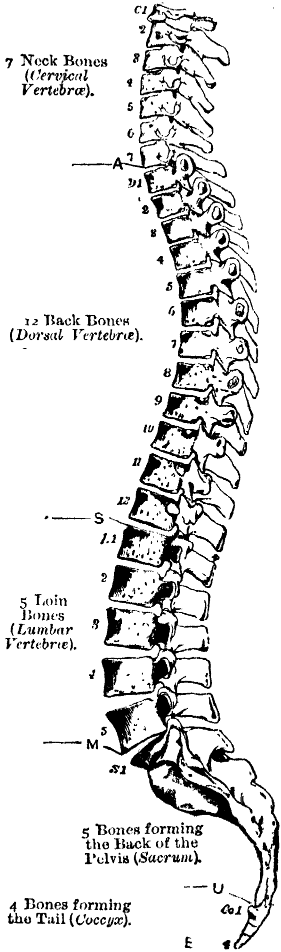


FIG. 9.—SHOWING A SIDE VIEW OF THE BACKBONE (VERTEBRAL COLUMN).
C 1. First cervical vertebra; D 1. First dorsal vertebra; L 1. First lumbar vertebra; S 1. First sacral vertebra; Co 1. First coccygeal vertebra.

Each of these different sorts of vertebra differ from

one another both in shape and in use. It would be too difficult for you to learn all the differences, but you can just notice how their bodies get larger as they get down.

Look how small is No. 1 of the Neck Bones (*cervical vertebræ*) compared to No. 5 of the Loin Bones (*lumbar vertebræ*). The lower ones are bigger and stronger, to enable them to bear the weight of those above them.

Again, you all know how rapidly and easily you can move your neck. You can turn your head from side to side, hold it up or down, lean it backward, or drop it till the chin touches the chest. That is partly because the neck bones (*cervical vertebræ*) are so many and so small, all seven only occupying a little more room than three of those of the big loin (*lumbar vertebræ*), but chiefly because the first two of the neck bones are quite differently shaped from all the rest, on purpose to allow of this sideways movement. The back cannot be moved so readily as the neck can be turned.

Some people's backs are much more lissome than those of others. You will all have seen the people in the circuses, how they bend their backs till they can put their heads on the ground, or how they tie their legs around their necks.

CHAPTER VII

THE BREAST-BONE OR STERNUM—THE RIBS

TO-DAY, children, you will learn about

The breast-bone (*sternum*) and **The ribs.**

Every one has a little hole or dent in front of the throat. If you put your finger on it and press it you soon feel a difficulty in breathing. Now put your middle finger on this place, and let your hand rest on your chest; your wrist will then just about reach to the end of your

Breast-bone (*sternum*).

Its top is made of spongy or cancellous bone, but the bottom is hardly bone at all; it is made of gristle, or what is called **cartilage.**

"What is cartilage?" once asked the little girl who had intelligently listened to her elders' talk about a neighbour's illness.

"Don't you know, Jenny? Girls never do know things. It is what you fire a gun with," said her brother.

"That is a cartridge, not cartilage," corrected their father, to the conceited boy's annoyance, and then he explained that cartilage was really only the long name which doctors give to gristle.

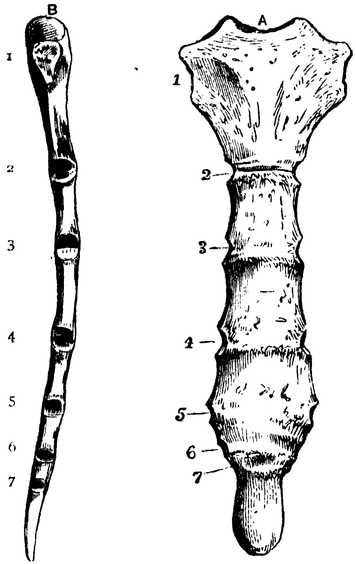


FIG. 10.—THE BREAST-BONE OR STERNUM.
(A, viewed from before; B, viewed from the right side.)
1, 2, 3, 4, 5, 6, and 7 are the surfaces to which the corresponding costal cartilages are attached.

Yes, but what is the use of it? Well, you must know that when you were babies the ends of all the bones in your arms and legs, as well as the ends of your ribs, were made of gristle. You all have a lot of gristle at the ends of your bones still, for it is not until people are quite grown up—over 21—that all their bones are fully formed. In some parts of the body we have cartilage all our life; it is never turned into bone, because a soft, yielding substance does just as well as a hard one. One of these places is the bottom of the breast-bone, and another is the side of the chest between the breast-bone (*sternum*) and the long ribs. Here

are some pictures in which you see what these bones are like and how they are joined together.

The Ribs

are the bones which go round the body like the hoops of a barrel or a tub.

There are twenty-four ribs in everybody's body—twelve on one side, and twelve on the other. They are curved bones, and are in pairs. One of the pairs starts from one side of the back-bone; the other of the pair starts from the other side of the back-bone. They curve round and meet each other in the front of the body, where some of them, not all, are joined to the sternum or breast-bone.

It would be much easier if each of the ribs started from the back-bone, and ended up with the breast-bone, or even if they each went all straight round like the

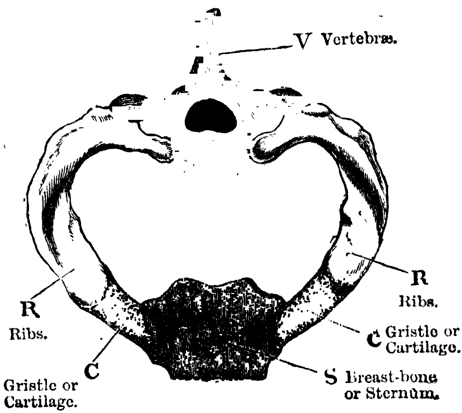


FIG. 11.—THE HOOPS OF BONE WITHIN THE BODY.

hoops of a barrel. If they did, we could just leave them, and not learn much more about them; but, alas! it is not so easy as all that, for, instead of being quite straight, they go a little downward. Look at the picture on page 26 and you will see what I mean.

The first 7 pairs are joined to the breast-bone at the places where the little figures are put in the picture. Count them, and you will find each of the seven fastened to the breast-bone. Ribs 8, 9, 10, are first joined to each other, and then fastened to Rib 7, which, you know, is the last one that is joined directly to the breast-bone.

Ribs 11 and 12 are loose; they are merely sticking out, and move about as required.

I should so like to show you all the beauties of the marvellous way in which the ribs are connected with the vertebral column at the back, with the breast-bone in the front, and also one with the other, but you cannot receive all this that I would give you. You are not yet old or clever enough, but you must try to understand and remember as much as I do tell you. I will show you a picture of a pair of ribs as they are joined to the breast-bone and back-bone.

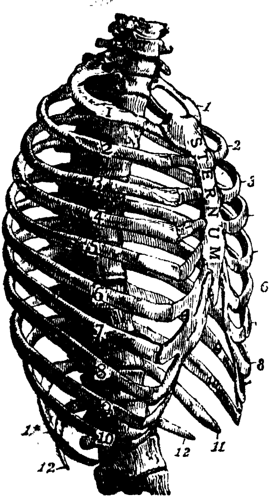


FIG. 12.—THE RIBS AND BREAST-BONE (*STERNUM*).

V is one of the bending bones or vertebræ, which when put together make up the spinal cord (*vertebral column*); *R R* are the ribs; *C C* is the cartilage; *S* is the breast-bone.

Now suppose we make a little experiment. Let each child stand straight upright, hold the book with the right hand, and lay the left hand on the chest. Now let every one draw a deep long breath. The back-bone has remained steady, but the ribs have moved and the sternum been lifted up by them so as to make more room for the air in the lungs underneath. Now let your breath out again—some of you have done so already, I see—and

what happened? The ribs moved down again; the sternum went back; there was less room behind it for the air in the lungs, so some of it had to go out into the room. This movement of the ribs is only one of two ways in which the air-space inside the chest is made larger or smaller, but it is the one that is most easy to understand, and therefore I am telling you about it now. In another chapter I shall tell you about the second way, and I shall also tell you what is the use of constantly letting the air come to and fro as we are all of us doing.

People often break their ribs. Sometimes the accident is very dangerous; sometimes it is soon cured. It all depends on which rib it is that is broken, and whether the broken bits of ribs stick outwards against the skin or turn inwards against the lung or heart.

CHAPTER VIII

THE BODY BASIN OR THE PELVIS

In the last chapter we likened the ribs to the hoops round a barrel; to-day we will learn about the sides of the barrel of the body. It is called the **pelvis**, and is something like a basin in shape, but is bottomless.

"A queer basin," you will say; and so it is. And it is something more than a basin. It is also a bridge and a box. Now turn to the picture on page 22, and notice that at the bottom of the back-bone there are five of the bending bones or vertebræ all joined together. They form one solid bone, ending with a short bone that sticks out by itself. This solid bone is called, as you have already learned, the Sacrum; it forms one of the four sides of the pelvis. On each side of it is

A hip bone (*ilium*).

You can easily feel them if you put your hands on your hips. These hip bones form the two sides of the pelvis. They are flat, narrow bones at the top, but they

soon alter and become thick and broad—so thick, indeed, that there is room for a large hollow or cup into which the cup of the big leg bone or femur fits.

Now, children, stand for a moment on your left leg, put your right hand on your right hip, and swing your right leg; your hand will be at the top of your hip bone, your leg will swing quite easily, the ball of the leg bone fitting into the cup of the hip bone just about the middle of the hip bone. This cup in the hip bone is called by a long and difficult name—the *acetabulum*. You will see it

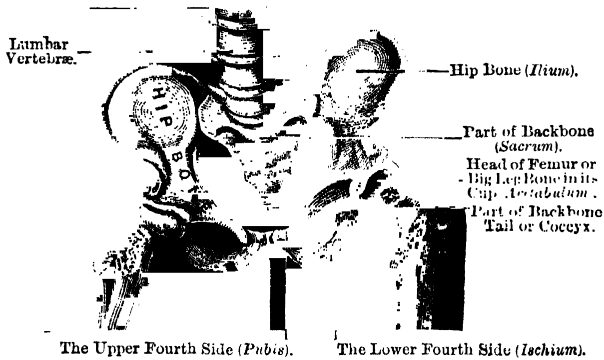


FIG. 13.—THE BODY BASIN—THE PELVIS.

on the right side of this picture. It is a long word; perhaps our teacher won't wish you to try and remember it.

Now we have got three sides of the bony bottomless basin of the body, called the Pelvis—

1. **At the back, the back-bone** (*sacrum*),

2, 3. **At the sides, the two hip bones.**

But there is yet a fourth and front side, and this is divided into two—

An upper front side (*pubis*). **A lower front side** (*ischium*).

Perhaps you will want to know what is the use of

giving these different parts of the pelvis such queer names, and so difficult to remember too. Well, if you like you needn't remember the names, but the reason why they have separate names is that when you are young they are really separate bones joined together by cartilage. It is not until you are grown up that the ilium, ischium, and pubes are all joined together by bone; and if you think you will have to learn the name of the big complicated bone which is made of all three put together, you will be quite mistaken. It is called the "**nameless bone**" (*Os Innominata*). Are not you glad? Well then, remember that the two nameless bones on each

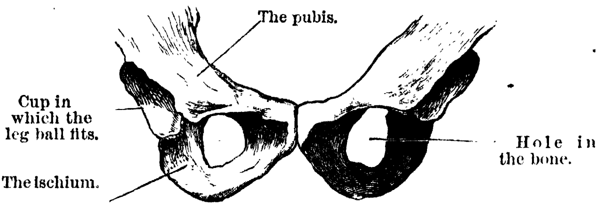


FIG. 14.—THE FRONT OF THE PELVIS.

side and in front, and the sacrum behind, form the **Pelvis**, which is a protection to the parts of the body inside, without being a box closing them in on all sides, just as a crate is protection enough for a bicycle which is being sent in a waggon or by train, although it is not a complete box. All the vital parts of our bodies—and by vital I mean those on which our life depends—are protected by bones.

The heart and lungs are protected by the ribs. The spinal cord, which has to do the great work of connecting the body with the brain, is well wrapped up. It goes through the tunnel of the spine, just like the string went through the reels of cotton (*spinal cord through vertebral column*). The brain is protected by a very strong bone box; and the pelvis, about which you have

been learning to-day, is the protection for many delicate organs.

But, besides its use in protecting, the pelvis has another use. It distributes the weight of the body. Let us suppose there was no pelvis. We could not then have two legs. The back-bone might be extended, and we should look like a snake or a fish, but legs would be impossible. Look at the picture of the skeleton and you will see my meaning. The pelvis is like the top of the bridge, the two legs being the two piers on which it stands.

When we talked about the back-bone, I showed you that the lower vertebræ were larger, and heavier, and stronger than the upper ones, so as to enable them to bear the weight of those above them. For the same reason, the bones of the pelvis have to be strong, for on them the whole weight of the upper part of the body rests. The pelvis takes upon itself the weight of the back-bone, and all the back-bone bears—such as the head, the arms, the shoulders—and dividing it, gives it in equal shares to the two legs to carry.

"Mary, don't stand on one leg," I heard a woman shout as I was riding past her cottage.

She spoke to her little girl, a pretty lassie, who was nursing a pretty kitten in a still prettier garden. I often admired the child, with her flaxen curls and graceful ways, but after a while I missed her from the garden gate, and on asking after her I found she was laid by with a spinal disease.

"The doctor says her leg has pushed up into her back," explained her mother, who had not learnt much physiology; but you, I hope, will see what had happened. Poor Mary had stood on one leg until the ball bone had pressed too hard into the cup (*acetabulum*) of the pelvis; that pushed her pelvis on one side, and curved the back-bone. The pelvis had done its duty in dividing the weight of the body between both legs, but she had made one leg do all the work.

CHAPTER IX

THE MUSCLES

HERE is a piece of elastic. Muscles are like it in three ways—

I. **Muscles can become longer, or expand.**
II. **Muscles can become shorter, or contract.**
III. **Muscles can remain as they are, or be stationary.**

All over the body there are muscles; they have different objects and different work to do; they are of different shapes and sizes. There are a great many, nearly five hundred, but broadly they are divided into two sorts—

1. **The willing muscles** (*voluntary striped*) obey our will.
2. **The wilful muscles** (*involuntary smooth*) act without our knowledge or control.

Every one has seen the muscles of animals; indeed, the lean of meat is nearly all composed of muscles. But we have yet to learn of what muscle is made. If we removed the two skins, the upper skin (*epidermis*) and the true skin (*dermis*), from any one of you—skinned you, in short—we should find under the skin the flesh, which is made of muscles.

Did you ever see a bit of the coarse part of the leg of beef boiled for such a long time that it is what people call stringy? Now, if you took one of these bits of stringy meat and boiled it again it would separate into still smaller strings, and a little patient working with a needle-point and a magnifying-glass would divide it into even finer threads.

The thinnest of these three sorts of threads is called *fibrillæ*. A number of these lying side by side make a *fibre*. A bundle of fibres makes a *fasciculus*. A number of these fasciculus (called *fasciculi*) make a muscle.

1. **The finest threads** (*fibrillæ*).
2. **A number of the finest threads** (*fibrillæ*) **lying together is a fibre.**
3. **A bundle of fibres is called a** *fasciculus*.
4. **A number of the bundles** (*fasciculi*) **make muscle.**

Here is a picture.

The little bit marked 1 shows the finest threads (*fibrillæ*); the part marked 2 shows how a fibre would look; while the whole thing round which I have drawn a line and marked 3 is part of a bundle (*fasciculus*), and a number of these (*fasciculi*) make the muscle or flesh. It is these little strings that grow shorter at our will.

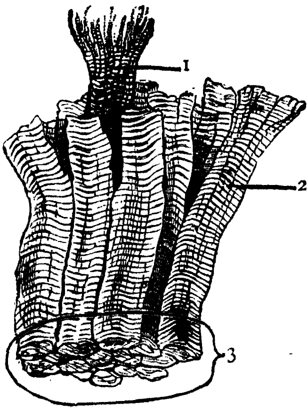


FIG. 15.—A PIECE OF MUSCLE AS SEEN THROUGH A STRONG MICROSCOPE.

"But you also said that muscles were smooth and striped. What makes muscles striped?" I shall, I hope, be asked. So far you have learnt how muscles look longways; now you will learn how they look if they are cut across.

Study this picture.

On the right-hand side of the page the drawing shows the top of the fibre, as if you looked down into it. The little round holes are intended to represent the finest threads (*fibrillæ*). On the left-hand side of the page there is a fibre cut across, or rather divided across. You see that there are layers put on each other in some ways like coils of rope, in other ways like a pile of biscuits. Like the biscuits in being flat and

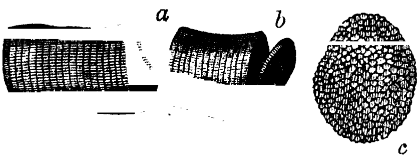


FIG. 16.—A FIBRE OF MUSCLE.
Showing the separate discs of which it is composed at *a* and *b*. The end of a fibre showing fibrillæ is seen at *c*. Very highly magnified.

thin, like the coils of rope in each one being connected with the other.

One part of the substance of which the fibre of the voluntary muscle is made is thicker than the other, and lets less light through it; so when the wise ones looked through the microscope they saw this sort of muscle look as if it were in stripes, and this is why it is called striped muscle (*striated*).

The wilful or involuntary muscles, although they do not obey our will, yet frequently respond to our feelings. "I will not obey you," they seem to say, "but I will sympathise with you." They contract, or come together, by sudden fright. When a person has been very much alarmed we sometimes hear that his "hair stood on end." People have often thought that this was just an expression to explain how frightened the poor creature was, but it is also a physiological fact. Fear will make the involuntary (*smooth unstriped*) muscles contract, and the hair will thus be pushed upwards and will stand on end.

One day I had to go and tell a dear friend that her father had unexpectedly died. He had been ill a long time, and she had devotedly given much thought to him; but nevertheless the shock was great. Her gentle face grew quite pale, and I thought she was going to faint. She turned white because the muscles of the blood-vessels, though they are involuntary muscles, reply to the feelings, and contract. The blood cannot then get through quickly enough, so the veins, little and big, become empty, and the complexion loses colour.

When a person has been very ill, and has spent a long time in bed, his muscles get weak, his legs and arms become what they call "flabby," but the doctors would say that "the muscles had lost their tonicity." The best cure for them is to use them; but sometimes the patient is too weak to do this, and then the doctor gives physic called "tonics," which are intended to help the muscles to regain their power of working or contracting.

CHAPTER X

THE WILLING OR VOLUNTARY MUSCLES

I WILL tell you in to-day's lesson about

The Willing (*Voluntary*) Muscles.

These are very obedient; they always do exactly as we tell them. Sometimes they do things without our knowing that we have told them; but that is only because we have told them so often that they have got used to acting without fresh commands. I think it is a very beautiful fact, and it should help us very much to know that our wills can command our bodies, that even our fingers move because we order our muscles to move them. It should help us in times of temptation, for though it is true to say "the flesh is weak," it is also true to say "the will is strong"; and as the poet has written it—

> "So near to glory is our dust,
> So nigh to God is man,
> That when Duty whispers, 'Lo! thou must,'
> The soul replies, 'I can.'"

Let us take an example. The willing or voluntary muscles that act on our fingers are chiefly of two kinds—

1. **Bending muscles** (*flexor*).
2. **Extending muscles** (*extensor*).

Look at your hands. You are perhaps each holding a book in your right hand. If the fingers and thumbs are closed, and kept closed so as to hold the book, you are using the bending (*flexor*) muscles. Open your hand and pass the book to your left hand. Now you have used the extending (*extensor*) muscles. Fig. 17 is a picture showing the muscles of the hand which will help you.

Both the bending (*flexor*) and the extending muscles (*extensor*) are voluntary. They obey your will. You wish and will that your hand shall close. The muscles inside it contract; the muscles at the back of the hand extend. The hand closes.

You wish and will that your hand shall open. The message flies from the brain—"Hand, open." The hand gets the order, and the muscles at the back of the hand contract or get smaller, like the bit of elastic. As they contract they pull the hand open; while at the same moment the muscles inside the hand get the same message, "Hand, open," and they extend or stretch, again resembling the elastic. At the same moment both the bending (*flexor*) muscles inside the hand and the extending (*extensor*) muscles outside on the back of the hand act, and their action causes the hand to open.

FIG. 17.—SHOWING THE MUSCLES OF THE HAND.

Your hands are not made of nothing but muscles. No; feel them and you will see that each finger has three bones through it, and that the hand itself is made up of many bones. The muscles are fastened to the bones, and pull them up or down as you command your hand to open or shut. To each finger-bone is fastened—

A bending muscle (*flexor*).
An extending muscle (*extensor*).

I will show you another example of this in the big muscle of the front of the arm. On page 36 is a picture of it.

You will notice that its lower end is fastened to a bone (*radius*) below the elbow, and that its upper end is divided and then fastened in two places to the shoulder-bone (*scapula*). The two bones of the fore-arm are able to move up and down at the elbow-joint if the upper

arm bone and the shoulder-bone are kept fixed by other muscles. I will suppose you to be standing in front of your teacher, each child holding this book in the right hand, while the left is held straight down by the side.

"Bend your left arm," says the teacher.

You wish to obey her orders, and your brain commands the bending muscle (*flexor*) in your arm to contract. It immediately obeys; and as it shrinks or

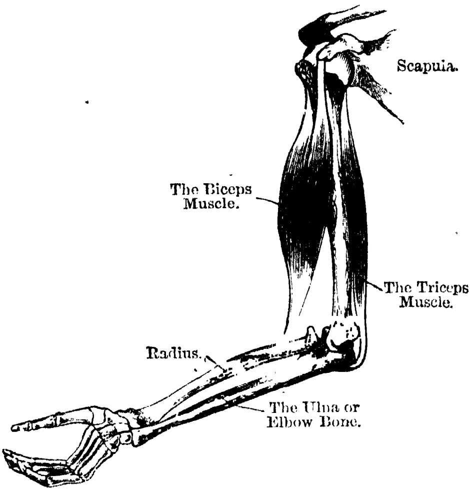


FIG. 18.—THE ARM, SHOWING THE BICEPS AND TRICEPS MUSCLES.

contracts it pulls up the bone (*radius*) into which its lower end is fastened, and, lo! your arm is bent.

"Straighten your arm," says the teacher.

"Extend," your brain says to your biceps, and it begins to obey. But you have to set another muscle to work before the arm will straighten. This contracting muscle lies at the back of the arm and is called the *triceps*. It is fastened to a bone below the elbow (*the ulna*). You will see it marked in the picture. At the

same time that you tell the muscle in front of your arm (*biceps*) to extend, you command the muscle at the back of your arm (*triceps*) to contract. Both immediately obey you, and the arm straightens.

The thick part that you see in the middle of the muscle in the picture, and that you can feel in your own arms if you try, is called the belly of the muscle. The thin parts at either end are not really muscle at all but **tendon**.

"What is a tendon?" you will ask.

Nothing very difficult to understand; only that the muscle when it gets thinner and is attached to the bone is called a tendon. "A tendon," as Professor Wilson says, "serves the same purpose as a rope to fix the muscle to that point of the bone from which it is intended to act."

FIG. 19.—THE LEG AND FOOT, SHOWING THE MUSCLES OF THE CALF.

Almost all these muscles which connect two bones are fastened to them by tendon. The place where the tendon is fastened to the bone which is fixed is called the **origin** of the muscle. The place where the tendon is fastened to the bone which moves is called its **insertion.**

You will see another example of this in the big calf muscle in the picture.

CHAPTER XI

THE WILFUL OR INVOLUNTARY MUSCLES

THE last chapter was about the willing or voluntary muscles. There are a great number in the body, but you were only told of a very few. Of two in the upper arm you learnt the names, the *biceps* and *triceps;* but there are many more, as you will see from the picture of the arm, which will give you some idea of the number and variety of these elastic bands which enable our limbs to move.

FIG. 20.—A BACK VIEW OF THE MUSCLES OF THE ARM.

When one is young the brain is not strong enough to take in much, and if I told you the names and uses of all these muscles you would not be able to remember them nor to understand the lesson; but the picture will teach you that there is a great deal more to learn about the body, and will help you to feel reverence for this wonderful work of Nature that you have to keep clean, healthy, and under control.

You will perhaps have seen old people with lumbago. They are bent down with pain.

"Ah! I have got the lumbago," they say.

You may have felt sorry, and perhaps you have tried to help them by pushing them upstairs, or fetching anything they may have wanted when they have once sat down, knowing that a move hurts them; but now you

will know what lumbago is. It is cold that causes stiffness in the lumbar muscles of the back, and if you turn to the skeleton, page 15, you will see where the lumbar vertebræ are, and guess from it, what is the truth, that the lumbar muscles are those near and around them. But now we will talk of

The Wilful (*involuntary*) Muscles.

These act and move and do their work whether we wish it or not. They do not move the limbs or the backbone or the head. They are none of them attached to bones. What is the use of them, then? you will say, and why do you call them muscles at all? One question at a time, please. The use of them is to send the food into our stomachs and beyond, where it can be absorbed, as you will learn in another lesson—to send the blood from the heart all round the body in the blood-vessels—in fact, wherever in the body substances have *to be sent through tubes*, it is done by these involuntary muscles. But why do you call them muscles at all? somebody said; they are not a bit like the picture of the biceps. No, but the biceps is a muscle because it is able to alter its shape, and in altering its shape to alter the position of the bones to which it is attached. The muscle in the wall of a blood-vessel is also able to alter its shape, and in so doing it makes the inside of the blood-vessel larger or smaller. If it makes it larger, the blood goes more slowly. If it makes it smaller, it goes more quickly. The heart itself is a great mass of involuntary muscle which, by altering its shape, alternately squeezes the blood out into the arteries and sucks the blood in from the veins. To all this we shall have to return in another lesson.

Now let us try an experiment. Has anybody got a hollow india-rubber ball? Make a hole in it and pour some water into it until it is nearly full. Now squeeze the ball in the hollow of your hand. The water comes out through the hole, and the harder you squeeze, the faster the water comes out. That is just what happens

when the heart is full of blood and its muscle contracts. It squeezes the blood out into the tubes which lead from it, and the more strongly the muscle contracts the faster is the blood squeezed out into these tubes. Now do you understand how a muscle can be hollow like a ball? These muscles—such as the heart—act without waiting to be told, and whether we will them to or no, and therefore we call them involuntary muscles.

If you were able to take a tiny slice of an ordinary muscle like the biceps, and another tiny slice of the muscle that surrounds a blood-vessel, and look at them both under a microscope, you would see a difference between them. When magnified by a microscope—

The willing or voluntary muscle is striped (*striated*).
The wilful or involuntary muscle is unstriped (*non-striated*).

It is always difficult to remember these sorts of differences; so, if you like, you can imagine that the striped muscles are like horses with reins, the unstriped muscles like horses without reins. It is the horses with the reins that can be pulled and made to move when we will. It is the muscles with the stripes which can be pulled by one's will and made move when we will.

Very useful are these wilful servants, for though I have given them this name they will only do what is right and helpful.

CHAPTER XII

THE HEAD AND ITS BONES

Everybody knows that the head is one of the most important parts of the body. It contains the brain, and it is also the seat of most of the senses. The ears by which we hear, the nose by which we smell, the eyes by which we see, the tongue by which we taste, are all parts of the head, while on its front side is situated the mouth, through which the body takes in food, air, and water,

which enable it to repair itself and also to grow. The head is divided into two parts—

The Skull (*cranium*). **The Face.**

The skull (*cranium*) is the long box which protects the brain, and it consists of eight bones. Their names are a little difficult, but the picture will help, and you must make up your mind to learn them.

The chief bones of the head are—

1. **The Forehead** (*Frontal Bone*).
2 and 3. **The Partition Bones** (*Parietal*).
4. **The Occipital Bone.**
5 and 6. **The Temples** (*Temporal Bones*).
7. **The Wedge Bone** (*Sphenoid*).
8. **The Sieve-like Bone** (*Ethmoid*).

You must now try and imagine a box with a bottom and a top to it, and four sides, but no square or right angular corners.

The Forehead (*Frontal Bone*)

is the bone that makes the front-head. It makes the front and a part of the top of the box. If the frontal bone sticks out it allows lots of room for the brain behind it to grow, and you will hear people say—"He ought to be clever; he has a good forehead." "A good forehead" does not necessarily mean that the person who has it is clever; for although he may have lots of room for his brain, he may not have used it, and it is only a well-used brain that makes a man clever. There are—

Two Partition Bones (*Parietal*),

one on each side of the head, and they make parts of the sides and part of the top of the head box.

The Occipital Bone

is the large one that lies immediately above the neck at the back of the head. It makes part of the back and a large part of the bottom of the box, for when it reaches the neck it does not abruptly end, but turns under, just as the bottom of a box is the continuation of the side. Right through this bone is a hole, about 1½ inches across,

through which the spinal cord passes, which, as you know, goes right down the back-bone as the cord went through the row of cotton reels.

The Two Temples (*Temporal Bones*)

lie, one on each side of the head, immediately behind each of the ears. They form part of the sides of the head box. The bone marked 7 in the picture is

The Wedge Bone (*Sphenoid*).

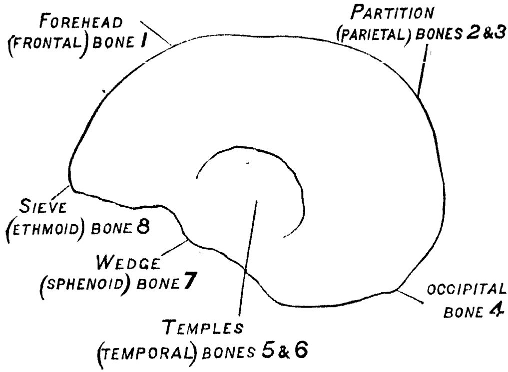


FIG. 21.—THE BRAIN BOX (SKULL), SHOWING THE POSITIONS OF ITS VARIOUS BONES.

The bone runs right through the head, and forms part of the bottom of the box. It starts just where the hair begins to grow on each side of the head, and goes behind the nose, and part of it forms the sockets of the eye. It is an irregular and complicated bone, too difficult in its structure for children to understand.

The Sieve-like Bone (*Ethmoid*)

is also a part of the side of the brain box. As you will see in the picture, it runs a little up towards the frontal bone. It gets its name because it is full of holes, through which nerves pass.

Here is a rough drawing of the brain box; but you will know that the lines of the bones are not really smooth,

even as they appear to be in the drawing. I have only made them so to help you to understand their different positions in the skull or brain box.

In the head of the little baby the bones are soft and not joined together, but the edges of each of the bones are jagged, and the place where they are joined is called a **Suture.**

Let one child put the book down and interlace the fingers, not allowing them to touch. It is something in

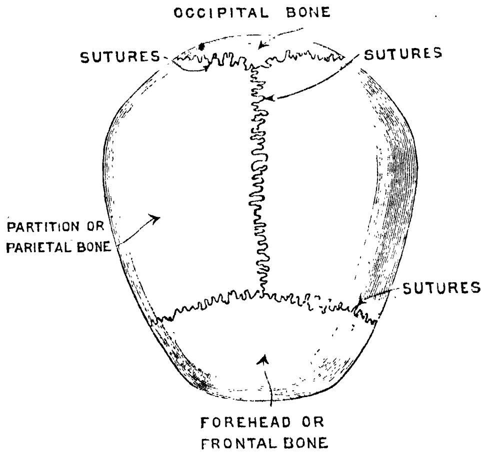


Fig. 22.—A View of the Top of the Brain Box (Skull), showing the Positions of the Bones and their Joins (Sutures).

this way that the bones in the head of a baby are placed; but the head-bones of grown-up people fit tightly together, far more tightly than your fingers can unite even if you interlace them ever so closely.

By the above picture you will see that the bones of the head are not laid side by side like two square pieces of wood. No! Each bone has uneven edges, which fit exactly into the uneven edges of the bone to which it is going to join.

When the little child is four years old these bones

become firmer and are closer together, but it is not until the child is seven years old that the skull, or brain box, is really hard and fitly joined together.

You will now see why it is not only cruel but foolish to box a boy's ears or to strike a little child on the head. The bones are soft, and a blow might cause injury to the brain which neither time nor medicine could cure. Indeed, it is not wise to let a little baby lie in its bed always on the same side of its body, for then one part only of its head touches the pillow. It might cause one side of its head to be smaller than the other, which would injure the brain. "I am afraid," said an ignorant nurse, "to wash the baby's head until the bones are joined, because washing has been known to give a child water in its brain." That is impossible, for though the bones are not joined together, they are covered with skin, muscles, and other coverings, so no water can get through. Everybody's head should be often washed, but the delicate skin of the dear baby should not be allowed to have even one day's dirt on it. It should be washed both morning and evening.

Many animals have bony boxes for their brains just as we have, and their heads, like ours, are the tenderest part of their bodies. Cruel drivers know this, and you often see a man, when he is in a rage, hit a horse or a donkey on the head. This is cowardly, as the poor beast can neither complain of the man's conduct, nor yet return the blow. If we have to hit any one, either a child or beast, the blow should fall on those parts of the body beneath the surface of which there are no vital organs. As the head contains so many and such delicate organs, it should never be subject to a blow or a knock.

Girls and boys who are allowed to carry baby must remember this, and take care not to hit its head against anything hard as they run or play.

CHAPTER XIII

THE FACE AND ITS BONES

THE face has 14 bones, but these are not very difficult to learn about, and if you hold your book in the left hand, and touch each bone as you learn about it with your right hand, you will find it easier to remember both their names and their positions.

Here is a list of them. The first 7 belong to the nose—

2 Nose Bones (*Nasal*).
2 Scroll-like Bones (*Inferior turbinated*).
2 Tear Bones (*Lachrymal*).
1 Ploughshare (*Vomer Bone*).
7
2 Cheek Bones (*Malar*).
2 Upper Jaw Bones (*Superior Maxillary*).
2 Roof of the Mouth (*Palate Bones*).
1 Lower Jaw Bone (*Inferior Maxillary*).
14 in all.

Now we will take them in order :—

Two Nose Bones (*Nasal*).—These bones form the bridge or hard part of the nose. You will see it in the picture; it is marked 1. You have heard of people who have fallen down and broken their noses. This is the bone which gets thus injured.

People do not very often break their noses, because if they fall forward they generally manage to save themselves by their hands; but sometimes a serious railway accident, or a kick from a horse, or a blow aimed in brutal savagery between the eyes, will result in a broken nose, namely, in the flattening of these two nasal bones.

The Two Scroll-like Bones (*Inferior turbinated*).—These bones are inside the nose. They twist about, so as to make the air, as it passes through the nose, have a longer journey. It may be asked—

"Why should the bone be so constructed that the air should have a longer journey?"

The reason is simple. The lungs are very beautiful and delicate organs. Every breath we take should go through the passage of the nose, which is made longer by the aid of the scroll-like bones (*Inferior turbinated*), till it reaches the mouth, goes down the throat, and into the lungs. The longer the air is in the body before it reaches the

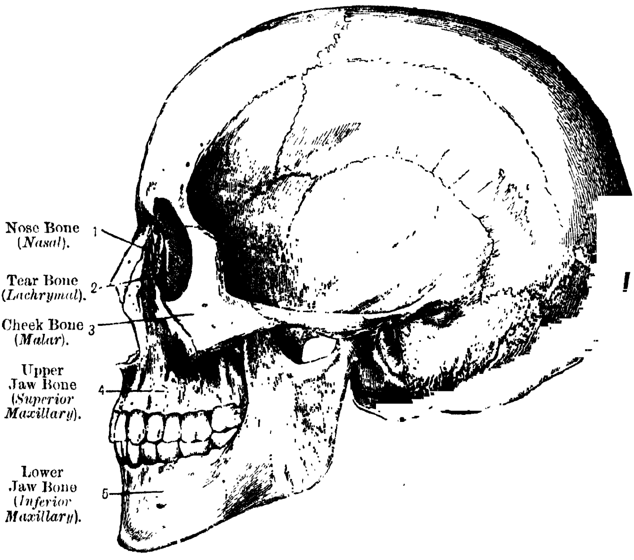


FIG. 23.—SIDE VIEW OF THE SKULL.

1. Nasal bones; 2. lachrymal bone, in the inner wall of the orbit; 3. malar or cheek bone; 4. upper jaw bone or superior maxillary; 5. lower jaw bone or inferior maxillary.

lungs, the more likely it is to be warm, and so the lungs will not be chilled by the cold or damp.

"She will never live to old age," an old servant said of one of my school-fellows. "She does not use her nose; she breathes through her mouth."

I do not suppose the old servant knew the reason of her opinion; but it was but too well founded, and my school-fellow died of some illness of the lungs before she

was twenty. She did not use her nose passages, but took her breath in by her mouth. While it was still cold and damp it went into her lungs, and gave them cold.

The Two Tear Bones (*Lachrymal*) are made like little troughs, and their duty is to carry the tears from the eyes to the nose. This is why people, who have so much pain and sorrow that they weep, frequently blow their noses. The tears are secreted in the eyes, and then run down the little channels in the lachrymal bones, and find their escape through the nose.

The lachrymal bone is marked 2 in the picture.

The Ploughshare (*Vomer Bone*) looks like that part of the farmer's plough which goes under the ground. You cannot find it in the picture, because it is inside the nose, its use being to run down the middle of the nose and divide it into two nostrils.

Very much depends on this bone whether the person's nose is large or small, long or short.

"She has an undeveloped vomer," you might say next time you wish to tell any one that So-and-so has a small nose, but I think it would sound very foolish if you did.

These are the seven bones which have to do with the nose, a small but most important feature, it being the means by which a person is often told what is good and what is harmful to him; for generally unwholesome things smell badly, and what is good is sweet-savoured.

The Two Cheek Bones (*Malar*) are marked 3 in the picture. You can easily find them in your own face, and see them in other people's. Some races have much higher cheek bones than others. Indeed, races are recognised by the difference in the shape and size of their face bones.

The Two Upper Jaw Bones (*Superior Maxillary Bones*).—Into these bones are fitted all the upper teeth, which it is to be hoped you use so well to chew your food. Wise men say each mouthful should be chewed thirty-eight times. The upper jaw bones are fixed and do not move, though doubtless most of you who read this chapter will have thought that both the jaws meet and move to grind the food.

The Two Roof of the Mouth Bones (*Palate*).—These

you cannot see in the picture, but you can feel them if you put your hand inside your mouth and direct it upwards. There are two, one on each side of the roof of the mouth. You may have heard of a "cleft palate." Little babies are sometimes born with it. It means that these two roof of the mouth (*palate*) bones have not joined together.

The Lower Jaw Bone (*Inferior Maxillary Bone*).—Into this bone is fixed all the lower teeth. It is able to move not only up and down like a pair of scissors, but from side to side. Ineeed, if you try you will find that not only can you make the lower jaw move up and down, and from one side to the other, but that it also has the power of moving round. This enables the teeth to churn the food, and to tear it, as well as to munch and chew it.

So much for the bones of the face, but I have a word to say about the expression;

> "God made me;
> I made my expression,"

has been said, and the two lines contain a great truth. You cannot alter the bones of your face. If you are a Chinaman, they will be of one shape; if you are a wild Red Indian, they will be another. If you are English, they will be different from either; but each one of you can make your expression. The soul looks out of the eyes. If it is a clean, pure soul the eyes will have a sweet expression. The character is written in the mouth. If the character is strong, true, energetic, the lines of the lips will tell its tale. Look to it, my scholars, that you so watch your thoughts, words, hopes, acts, that your faces, however the bones are formed, will have the beauty of goodness, purity, and love.

CHAPTER XIV

THE BRAIN

ITS COVERS—OUTSIDE AND INSIDE THE SKULL

INSIDE the head box lies the brain, that delicate and marvellous structure by the aid of which we move, and think, and know what we feel.

1. Without the brain we could not learn nor understand anything. 2. Without the brain we could not will to move. 3. Without the brain we could not remember, and all the rich stores of experience and facts which other people have gathered would be lost to us. 4. Without the brain we could not invent, nor hope, nor love.

This wonderful organ is very delicate, so delicate that even a sharp blow on its box—the skull—sometimes injures and upsets it. Thus it has to have many coverings, eight in all. There are—

Two Coverings outside the Skull.
Three Coverings inside the Skull.

The names of the two skull outside coverings are

The **Hair** and the **Scalp.**

We will consider the **hair** first. Let each child look at another, or at the teacher, and the eyes will rest on the hair. This is the first of the skull coverings. It is true of all parts of these wonderful bodies of ours that the more one knows about them the more interesting they become, and this chapter could be very well used in learning only about this one of the head coverings, so much is there to know and understand about it alone. I wonder at which end you think your hair grows. As it gets longer do you think it is added to at the end you see, or at the end that is in your head? Fig. 24 is a picture of it.

You will not have forgotten the lessons on the skin and muscles, and so the picture will be understood.

You will see the upper skin (*epidermis*) and the true skin (*dermis*). You will be able to follow the sweat glands and ducts and pores, the fat cells, and the hillocks (*papillæ*), but you will not know about the hair nor its

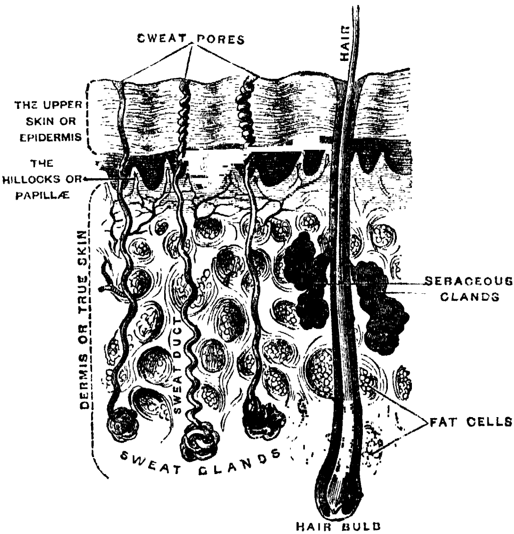


FIG. 24.—SECTION OF THE SKIN, SHOWING THE HAIR ROOTS, FOLLICLES, AND GREASE GLANDS (SEBACEOUS).

glands, so I must tell you that near the root of each hair are two little glands called

The Grease (*Sebaceous*) Glands.

They make or secrete a sort of oil which greases not only the hair but the surrounding skin. Brushing the hair stimulates or enlivens these little glands and makes them give out more oil, and that is the reason why well-brushed hair always looks glossy. There is no need to

put grease or oil on the hair, for Mother Nature has provided everybody with numberless little bottles of the best sort of pomatum. Each hair consists of two parts :—

a. **The Root** (*or Bulb*). *b.* **The Shaft** (*or Stem*).

We will consider them one at a time. Look at this picture; it is of

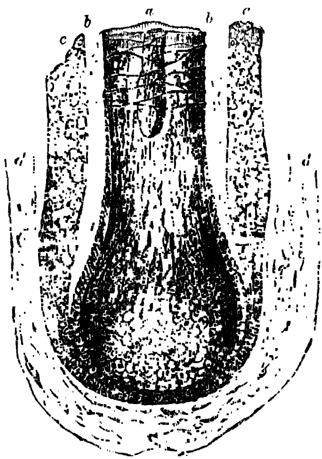


FIG. 25.—THE ROOT (OR BULB).

and consists of three parts :—

1. **A root,** which is enclosed in
2. **A little bag** (*called a follicle*), at the bottom of which is
3. **A projection** (*papilla*).

The projection (*papillæ*) is well supplied with blood-vessels. From it are created little fresh new cells. Each new one pushes the older one forward as a new one is created, and this new one in its turn becomes an old one as a still newer one comes into being, and these little cells make new hair. So you see the hair near the end is the old hair; the hair near the head is the new fresh young hair.

The Shaft (*or Stem*)

of the hair is the part which we all see. Long and thick hair is such a great beauty, that it is curious why more girls do not take pains to obtain it. Frequent brushing and washing in warm water with soda are the best ways to get good, long, and thick hair.

The people in different countries have different ideas about hair. The women in Egypt and the Eastern lands do not think it modest or becoming to show any hair at all, and they cover their heads and ears with long draping cloths, while the ladies of Japan undergo the most elaborate hair-dressing. Indeed, the process takes so long a time that it is not usually done more than once or twice a week. Each hair is brushed and pomatumed and gummed until it lies in its proper place. To rest the head on a pillow would upset it all, so the Japanese women forego pillows, and sleep by resting their heads on small neck-rests, which allow the hair to remain untouched. Is it not a strange custom?

The second covering of the skull is called the **Scalp.**

There is but little need to pause over the scalp, for you have already read something about the skin, fat glands, and the muscles, and when these form the scalp they are not essentially different than when elsewhere. But I should like you to carefully study the picture (Fig. 24), from which you will see how the hair roots and the grease (*sebaceous*) glands lie in amid the fat cells, sweat pores, sweat glands, and sweat ducts.

I have seen these Red Indians in their own homes in Canada, if one can use the beautiful word home for their miserable tent huts. One man, called "The Mountain Bull," was pointed out to us, who boasted that he had got the scalps of fifteen men in his tent. I do not know if it was true, for these savages know but little more about the law against lying than they do about the law against killing.

But the brain has six coverings in all. You have heard about the two outside the skull, the hair and the scalp. The skull itself is the third, and now you must

learn about the three coverings inside the skull. They are—

1. **The Hard Mother Covering** (*Dura Mater*).
2. **The Spider-Web Covering** (*Arachnoid*).
3. **The Pious Mother Covering** (*Pia Mater*).

We will talk about each one separately.

1. The Hard Mother Covering (*Dura Mater*)

is a tough, strong skin, each side of which is different. The side which touches the skull is rough and uneven. It clings to the bone, and is, as it were, the lining. On its other side, the side nearer the brain, it is soft and smooth.

It has a curious name, has it not? the idea in it being that it did the mother's work of closely protecting the delicate brain, although it was rough and hard.

2. The Spider's-Web Covering (*Arachnoid*)

is really a delicate network containing a fluid. This covering is very sensitive yet effective. If by any accident the head receives a blow, this fluid will do something to prevent the brain feeling the shock of the blow. Underneath this spider's-web or network (*arachnoid*) is the third covering,

3. The Pious Mother (*Pia Mater*).

Is not this a pretty name?

Perhaps it has been given to it because the old meaning of the word pious was "devoted," and those who are devoted love to give. The brain requires a great deal of blood, and it is the pious mother covering (*pia mater*) which supplies the brain with all the blood it needs to enable it to do its difficult, hard, and yet delicate work. The brain flesh, or substance, is not flat and smooth like an arm or a leg. It is all crumpled up like a tumbled piece of paper. These crumples are called

The Convolutions of the Brain,

and around each of these convolutions the pious mother (*pia mater*) puts her gentle arms, giving to each and all the necessary blood, for each fold takes food and nourishment from the many blood-vessels of the pious mother,

and so the whole brain gets more than it would do if it were flat.

If you were to see inside the head, you would be surprised to find the brain moving. It moves every time the

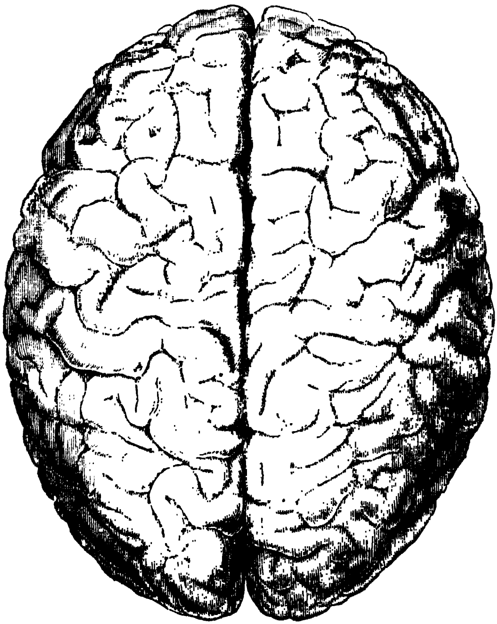


FIG. 26.—THE UPPER SURFACE OF THE BIG BRAIN (CEREBRUM), SHOWING ITS DIVISION INTO TWO HEMISPHERES, AND ALSO THE CONVOLUTIONS.

heart beats. Then the pious mother (*pia mater*) calls up the blood and pours it into the thousands of little tiny vessels that feed the brain, and as she does so the spider web (*arachnoid*) moves too, so as to give the blood room to flow into and feed the brain. Each covering does its own work, but all in harmony.

The pious mother (*pia mater*) feeds the brain.

The fluid (*arachnoid*) guards it from any shock.

The hard mother (*dura mater*) protects not only the brain itself, but also both the other coverings.

On page 54 is a picture showing the convolutions of the brain.

And now that you have learnt a little about the brain, which is so delicate that it requires so many coverings, I hope you will be careful about the head. Sometimes elder girls or boys left in charge of little ones carry them so carelessly that the little heads get bumped; or if they are tiresome, the ears are boxed. This is neither wise nor kind, for though the brain has six coverings, it needs them all for its protection, and the jar of a blow often does harm to the brain which cannot be repaired.

You will also, I hope, remember that the brains of animals are in their heads, and that it is cruel and cowardly to hit them there. There is a great deal of pain in the world, pain caused by illness, death, misfortune, and pain caused by the saddest of all things, the wrong-doing of those we love. Much of this sadness cannot be avoided, so it is all the more necessary that we should each avoid giving pain when we need not do so.

CHAPTER XV

THE BRAIN

THE BIG BRAIN AND ITS CHAMBERS

THE skull is the box in which the brain is packed. About that you have learnt something. To-day we will speak about the brain, which is divided into four parts—

1. **The Great Brain** (*Cerebrum*).
2. **The Little Brain** (*Cerebellum*).
3. **The Oblong Marrow** (*Medulla Oblongata*).
4. **The Brain Bridge** (*Pons Varolii*).

By the time a boy is fourteen years old his brain weighs as much as that of a full-grown man, namely about forty-

five ounces, or three pounds. When people have studied and thought a great deal, their brains weigh more; indeed, the brains of some clever men have been known to weigh over sixty ounces, while that of a poor idiot is only fifteen ounces. Look again at the last picture, and turn on to page 73, where you will find another. Almost all the brain here shown is *cerebrum.* Indeed, compared to it the other parts of the brain are very small. But we could not get on without them, so I will show you another picture in which these other parts have been pulled down out of their proper position on purpose for you to see what they look like.

The Big Brain (*Cerebrum*) lies at the top of the head, indeed, it occupies most of the skull. It begins just

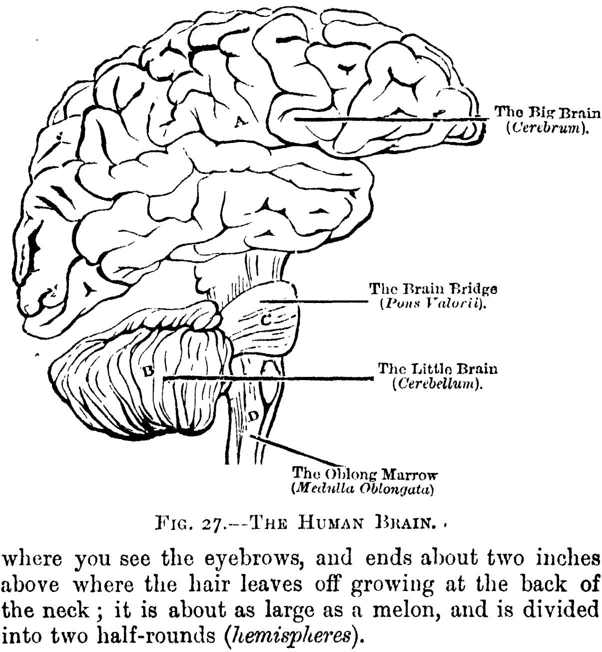


FIG. 27.—THE HUMAN BRAIN.

where you see the eyebrows, and ends about two inches above where the hair leaves off growing at the back of the neck; it is about as large as a melon, and is divided into two half-rounds (*hemispheres*).

There are three ways in which the big brain is necessary to our life.

1. Without it we could not think or remember anything. People who are stunned by a blow on the head are quite unconscious until the brain begins to recover and remembers,—not the blow which sent it to sleep, but what happened just before the blow.

2. Without it we could neither see nor hear, nor smell, nor taste, nor feel. These are the five senses, you know, and each of them is dependent not only on the eye, or the ear, or the nose, or the tongue, or the skin, but on either some particular part or on the whole of the big brain.

3. Without it we could not move or use any of the voluntary muscles of which we were talking not long ago. There is a particular part of the big brain which is especially connected with the power over these voluntary muscles. This we will call the Motor portion.

If at this moment some one were to tread on your toe, you would at once move your foot. Perhaps, if you wanted sympathy, or were very much hurt, you would make a wry face. If you thought the some one had trodden on you purposely, you would be inclined to push him away or hit him; and if you thought he had done it carelessly, you would tell him to be careful; or if you were unkind or un-Christian, you would perhaps abuse him and be rude to him.

Will it surprise you very much to learn that the big brain (*cerebrum*) and the oblong marrow (*medulla oblongata*) have both been at work to enable you to do or feel any of these things?

Your toe is trodden on. It itself could not feel anything, but at once the brain (*cerebrum*) is told that your foot is hurt, and in your brain you feel the pain that is in your foot. Directly the big brain (*cerebrum*) learns that your foot is in pain, a message is sent from that part which is called the motor portion, to bid the foot move. Down the oblong marrow (*medulla oblongata*) goes the message. The foot is accordingly moved, but a message goes back again once more, through the oblong

marrow (*medulla oblongata*) to the brain to say the pain goes on. The thought now arises—

"I must show that I am hurt," and accordingly from the motor portion goes the message—

"Contract the muscles of the face."

The message is sent to the face, the muscles are moved, and a wry grimace is made.

That done, a new idea occurs, namely—

"Hit the person who trod on your foot."

"Quick as thought," we say, and it is a good expression, for along some nerves the force travels at the rate of 140 feet to a second. Quick as thought the idea passes to the motor portion of the big brain (*cerebrum*) and from it goes the command to the arm—

"Contract the muscles, lift the arm, and push or hit the person who trod on my foot."

At the same moment, or almost the same moment, the idea arises to speak to the careless one. Just what goes on in the brain when we have an idea we do not at all know, but whatever it is, it gives rise to an order which is at once passed on to the motor portion of the brain, and words are the result. We all know that it is given to each one of us to control our speech, so that if we will we may command that from our lips should not come the angry, hard words, but a "soft answer which turneth away wrath."

CHAPTER XVI

THE BRAIN

THE LITTLE BRAIN—THE OBLONG MARROW—THE BRIDGE.

In the last chapter you learned about the big brain and some of its uses and works.

To-day I hope you will learn something about

The Little Brain (*Cerebellum*).
The Oblong Marrow (*Medulla Oblongata*).
The Bridge (*Pons Varolii*).

Each is different, not only in shape and structure, but in object and use. We will begin with—

The Little Brain (*Cerebellum*), which is much smaller than the big brain (*cerebrum*). It is situated immediately below it and extends from about the back of one ear to the back of the other ear on the opposite side of the head, lying, as it were, just at the top of the neck, and is about as big as a medium-sized orange.

No one yet knows quite all the uses of the little brain (*cerebellum*), but it has been proved that it has a great deal to do with the power of walking and running.

To stand upright is a very difficult matter. I daresay it seems to you quite easy to do so, but if you notice you will see that most animals with four limbs use them all for walking. The human being only uses his hind legs for walking, and thus he has his front ones, or arms, as we prefer to call them, free for other purposes.

The power of balancing ourselves and managing our muscles when we walk or run resides in the little brain (*cerebellum*). The knowledge of how to do it is learnt unconsciously, partly by example, and partly because our parents have always done it before us; but if by any accident the little brain (*cerebellum*) is injured, the poor patient no longer is able to manage his muscles, and his limbs go in all sorts of directions.

There was once an old lady whose little brain (*cerebellum*) had been injured, and she had therefore, to some extent, lost the power of controlling her muscles. She used to fancy she was leaning forward and going to fall when she was quite upright, and she would sometimes hit herself against the table or mantelpiece because she had not understood she was so close to them.

Her big brain (*cerebrum*), her oblong marrow (*medulla oblongata*), her bridge (*pons varolii*) were all in good health, but she was powerless to be useful, and so was unhappy because her little brain (*cerebellum*) having got an injury, she could no longer get her body to obey her will.

The Oblong Marrow (*Medulla Oblongata*) is placed at the top of the back-bone, through which, you will remember, the spinal cord runs. Indeed, the oblong marrow (*medulla

oblongata) is only the enlarged end of the spinal cord as it enters the head.

It is the most important of the four parts of the brain, for if it is injured instant death takes place. It is, as you will remember, the end of the spinal cord. It is about an inch and a half long, and half an inch thick, and if you will look at the picture you will see it is rather broader at the end where it joins the other parts of the brain than it is where it is enclosed in the spine (*vertebral column*), and called the spinal cord.

Just as the little brain (*cerebellum*) governs the muscles of the limbs, the oblong marrow (*medulla oblongata*) governs the muscles of the lungs and the heart, as well as those that are used in swallowing. It has some control also over the secretion of the spittle, as well as the organs for tasting, seeing, hearing, and talking. Altogether, this inch and a half bit of brain is an important governor in the kingdom of our body.

In different countries there are different ways of executing criminals. In Burmah the executioner hits the condemned person a sharp and hard blow at the back of the neck, under which is placed the oblong marrow. It is not painful, and death is instantaneous, for you know we cannot live without breath; and if the oblong marrow (*medulla oblongata*) is injured the lungs stop working, and as air is necessary to life, the person whose "neck has been broken," as we say when the oblong marrow (*medulla oblongata*) has been injured, dies at once. There are other reasons why this part of the brain is so important, but you must learn of them when we come to the chapter on the nerves.

The Brain Bridge (*Pons Varolii*) is, as its name shows, a bridge which connects the two parts of the little brain (*cerebellum*) together.

"Two parts," I seem to hear you say; "we did not know that the little brain had two parts."

Yes; both the big brain (*cerebrum*) and the little brain (*cerebellum*) are divided into two halves. You will see the picture of the big brain on p. 54. Each half is called

The Half-round or Hemisphere of the Brain,

and it is separated from the other half by a deep cleft or chasm. The bridge (*pons varolii*) connects the two hemispheres of the little brain (*cerebellum*).

Right in between them, sharply dividing the two parts, runs the oblong marrow (*medulla oblongata*), and yet if they are to do their work properly they must be joined. To unite them is the object of the bridge (*pons varolii*), so it reaches right across the dividing medulla and acts as their link.

All animals have brains of different sorts, but the brain in human heads has more creases, or convolutions, as they are called, than any other animal.

The brain can be altered by study, and a boy or girl who is really diligent can improve both the quantity and quality of their brains. "I am too stupid to learn that," every teacher has heard said; and having so spoken the student gives up trying.

But to say this is neither true nor wise. Education exercises the brain, and use will make it grow, just like the blacksmith's arms or the legs of the Japanese men-ponies grew when they were well exercised.

No, dear boys and girls, do not believe that you are too stupid to learn anything. Of course, we all know that some people are much cleverer than others, but that only means that the less clever ones have to take more trouble before they understand a thing than those who have more natural power.

"He has good brains," is sometimes said of a child; but it is better still to hear it said—

"She never gives up, but is always trying."

CHAPTER XVII

THE JOURNEY OF A SENSATION

THE BRAIN'S MESSENGERS—THE NERVE STORE-ROOMS

In the last chapters mention was made of the messages that were sent from the brain to the various parts of the body.

"Who carried these messages?"

"Why, I knew my toe was trodden on," some one will perhaps answer.

Yes; your big brain (*cerebrum*) knew, but who told it? How does our brain know, even when we are asleep and our will is not working, that the coverlid has fallen off, or that some one has touched our hand? The brain knows because the nerves have told it; and now I will try and teach you something about your nerves, what they are and what they do.

We will speak to-day about

Nerve Fibres.

If you were to see a nerve, it would look something like a bit of fine white cotton, but if, after a person is dead, you could see one of his nerves through a magnifying-glass, it would look, not like one bit of cotton, but many. Each thread would appear something like a very tiny glass tube filled with oil.

Did you ever see one of the big cables by which the ships are fastened to the piers? If it is cut, or broken, you will see that although it is only one rope, it really consists of many strings or strands, as they are called, each lying side by side, and then twisted together. Something in this way is made the telegraph cable, through which the messages go under the sea to America and the Colonies.

"But the telegraph cable is something more than strings or strands?"

Yes; sunk deep amid the strands of the cable or rope, well covered up, is the wire by which the message is sent.

A nerve fibre is something like a telegraph cable. It is composed of three parts—

a. **The Central Part** (*Axis Cylinder*).
b. **The White Substance** surrounding the Central Part.
c. **The Sheath of Swann** surrounding the other two parts.

The nerve fibre is a very tiny pipe. It is so small that you could not see it without a microscope, but it contains a sort of fluid (*axis cylinder*).

You have all heard, I hope, of Professor Huxley, that

great man, who has learnt so much and taught so much about Nature's laws. He says, in speaking of the central part (*axis cylinder*) of a nerve—

"Imagine a telegraph cable made of delicate indiarubber tubes filled with mercury—a squeeze would interrupt the electrical continuity of the cable without destroying its physical continuity."

Later in the lesson I will further explain this to you.

The White Substance is the coat of the delicate tube. It protects it, and over both is

The Swann Sheath, so called because a Mr. Swann was the first gentleman to discover its existence.

Here is a picture of white nerve fibres.

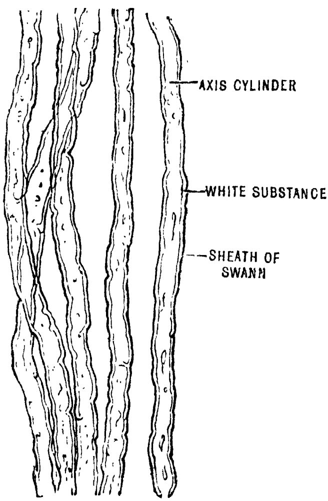


FIG. 28.—WHITE NERVE FIBRES, SHOWING THE AXIS CYLINDER, WHITE SUBSTANCE, AND SHEATH OF SWANN (MUCH MAGNIFIED).

But nerve fibres are not nerves. Each strand of a rope is not a rope, though it goes towards making one. There must be many laid side by side, and in the same way there must be quite a little bundle of nerve fibres all laid together before we can have

A Nerve.

The nerves have for their work that of messengers; to all parts of the body do they run, not only to those parts which we can see, like the hands, arms, legs, and face, but they are also to be found around every organ inside the body—the heart, the lungs, the liver.

Each and every organ has its messengers, the nerves. They are of various sizes. At the nerve trunk they are

quite large, and then they divide and subdivide until they become very tiny, like the finest hairs.

There are two sorts of nerve fibres, and they are called

The Carrying-to Nerves (*Afferent*).
The Carrying-from Nerves (*Efferent*).

Each has its separate and distinct work. You will remember that when we talked of the brain, you were told that to one part of it was carried the news that your toe was trodden on, and from another part of it went the order—

"Move the foot."

Now it was a carrying-to (*afferent*) nerve that carried the news to your brain (*sensory portion*); through it was flashed the fact that pain was felt in your foot. The brain (*motor portion*) gave the order for the foot to be moved, and sent out its order by a carrying-from (*efferent*) nerve. Thus you see that both kinds of nerves have their uses.

Did you ever have the curious sensation in any of your limbs that is called "going to sleep." It is caused by the nerves not doing their duty.

A friend of mine was going for a tour in France. He hoped to see the beautiful churches and cathedrals and to enjoy studying the various styles of architecture which are to be seen there. When he left Dover the sea was blue and sparkling, and he went up to the extreme end of the bow to watch the ship cut the waves that danced gaily around her. Soon, however, the wind arose, and it became so rough that our friend was made very sea-sick. He lay down, hoping soon to feel better; but he got worse and worse, till when they reached land he had to be carried ashore.

He soon got over the sea-sickness, but he had lain on his right arm till it had "gone to sleep," and it would not awaken. By lying on his arm the little tubes had been flattened. Their walls were pressed together so that the central part was squeezed too tightly, and the road was not clear for the messages to be flashed up and down to the brain.

Sometimes the bundles of nerve fibres that go to make

up a nerve contain both afferent (*carrying-to*) and efferent (*carrying-from*) fibres. When this is the case they are called **Mixed Nerves**, of which there are a great many all over the body.

CHAPTER XVIII

THE JOURNEY OF A SENSATION

FORCE FACTORIES—NERVE CELLS

The last chapter was devoted to nerve fibres, their structure and their work; to-day our talk will have to be about

Nerve Cells.

Here is a picture of one.

Now to the nerve cells is given a very different duty from that of the nerve fibres.

The Nerve Fibres are carriers, but The Nerve Cells are stores of food specially prepared for the fibres.

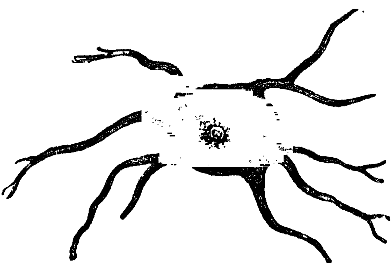


Fig. 29.—A Nerve Cell.

Some of the branches that you see in the picture are the beginnings of nerve fibres, and if any one of them were cut off from the cell it could not get food any longer, so it would die and the messages to or from the particular part where that fibre went would not get carried at all. If it went to a muscle we should not be able to move the muscle so easily. If it went to the skin, there might be a particular part of the skin where we should not feel the prick of a pin.

You may have heard of people who are nervous.

"Poor thing," people say, "her nerves are weak;" and the person of whom this is said is easily frightened, often tired, and has little courage and energy, or what we English

people know as "pluck." This sad and wearying condition is caused because the nerve cells are weak. If you look in the picture you will see how the tails of the nerves stick out, and how vigorous and alive they look. If you saw a picture of these same nerve cells when they were weak, you would see the tails drooping, and the centre part would seem limp and flabby.

Many learned people have tried to find out where memory, thought, and will dwell in the brain, but it has not yet been discovered, though it is generally believed that the brain cells, and the condition of their tails, have something to do with all three.

Have you ever had a long illness? If so, you will know how, after it, not only your body feels weak, but your brain seems useless and incapable.

"I can't understand it," you say. "I could have done so before I was ill, but now I can't."

"Never mind," says the kind friend who is tending you; "it will come back to you."

If the explanation was given, it would mean that the brain cells and their tails were weak, and could not work, either to carry facts, or to create thoughts about the facts.

When people get old the cell tails wear out, and then they are apt to forget.

"It is no use," you will hear an old person say; "I can't recall it now, though time was when I knew it well."

His brain cell tails are worn out, and can't carry the memory stores; but sometimes it will come to him "in a flash" long after he has left off thinking about it. That may be because the tails of those brain cells that are not worn out have been set to work, and at last have succeeded in hunting out from a brain cell the memory he wanted.

This picture will show you how certain brain cell tails could in this way help other brain cells which have had their tails worn out or injured. As you will see, the tails interlace and touch each other, and so the idea that could not pass from one cell because its tails are feeble or worn out is sometimes able to use the tails of other centres, and travel along them.

Nerve Fibres are white generally (but not in all cases).
Nerve Cells are grey,

and are placed in the brain and the spinal cord. On

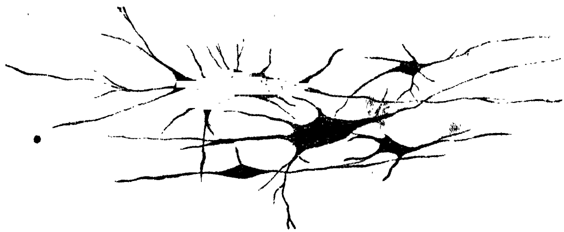


FIG. 30.—NERVE CELLS, SHOWING THEIR TAILS INTERLACING.

each side of the backbone there is also a row of them

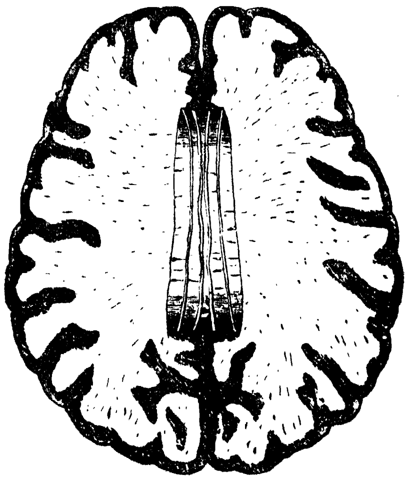


FIG. 31.—SECTION THROUGH THE BRAIN HALF ROUNDS (*CEREBRAL HEMISPHERES*), SHOWING THE ARRANGEMENT OF THE WHITE AND GREY MATTER.

Here is a picture which will show you how the grey and the white matter are arranged in the brain.

You have seen pictures of a nerve fibre and nerve

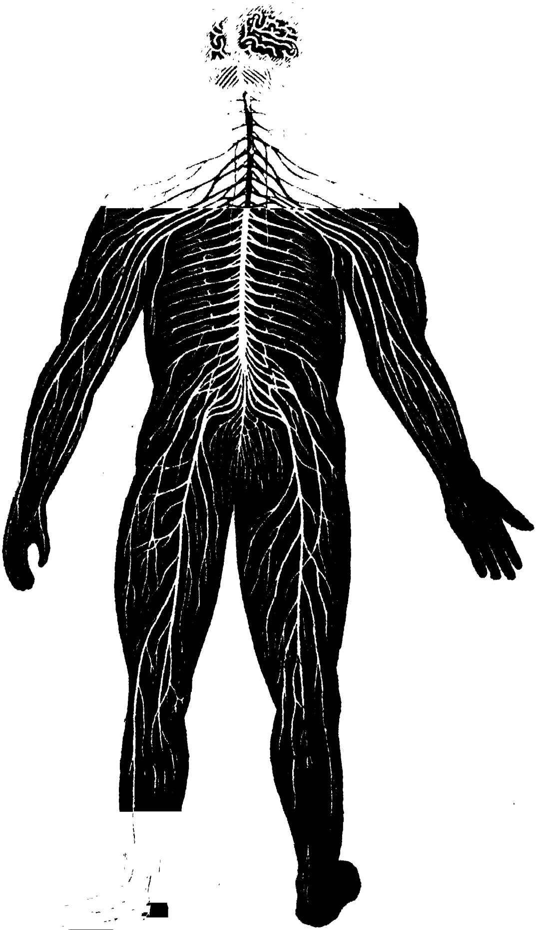


FIG. 32.—THE CEREBRO-SPINAL SYSTEM.

cells. Now here is a picture showing how the nerves go all over the body.

You will notice how thick is the nerve trunk (*spinal cord*) and how tiny are some of the nerves that go into the fingers, and toes, and face. Many as there are in this picture, there are yet thousands more than can be shown here.

CHAPTER XIX

THE JOURNEY OF THE SENSATIONS

THE SPINAL CORD—ITS MESSAGES AND COMMANDS

You will remember that you were told that when any part of the body was touched, the carrying-to (*afferent*) nerve carried the message that it was touched to the brain.

I did not then stop to tell you by which road the carriers travelled, but now you must learn that they first had to get between the bones of the spinal column, right into the very centre of it. Once there, up they rushed till they reached its thick end, the oblong marrow (*medulla oblongata*). Through that they sped until they arrived at the brain, gave their news, and found the carrying-from (*efferent*) nerves awaiting to receive orders from the brain.

That was the road they took; but I hope some one will be wondering how the little postmen got into the spinal cord. If so, now is the time for wondering to cease and knowledge to begin.

The Spinal Cord

is the continuation of the oblong marrow (*medulla oblongata*). In grown-up people it is about eighteen inches long, and almost as thick as one of their middle fingers. It is covered with the same coverings as the brain, but

they are not arranged in exactly the same way as they are when they enclose the brain itself.

The brain is in the bony box of the skull which covers and protects it, and the spinal cord is packed in the bony box of the back-bone, which enwraps it and saves it from rough usage.

You will not have forgotten what you learnt about the back-bone (*vertebral column*), and that we imagined it to resemble a row of cotton reels (*vertebræ*) threaded together by a bit of string. Down the middle of the back-bone, through the holes in the centre of each of the bones, goes the spinal cord. It is composed of

Nerve Fibres—carriers.
Nerve Cells—feeders.

Between each one of the reels (*vertebræ*) there go in and come out a pair of nerves—sixty-two in all. Thirty-one go to the right-hand side of the body, thirty-one find their way to the left-hand side of the body.

These nerves are called the spinal nerves. Each one has

A Back Root (*posterior*). **A Front Root** (*anterior*).

Here is a picture of two pairs of nerves coming out from between the reels (*vertebræ*) of the back-bone.

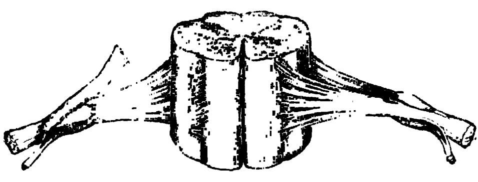


FIG. 33.—NERVES ENTERING IN AND ISSUING FROM THE SPINAL CORD.

Very soon after they come from the spinal cord they join together, and then they are called **a nerve trunk.**

It is the nerves that come through the front (*anterior*) holes that carry the commands about movement *from* the grey matter of the brain or spinal cord. It is the nerves

which come through the back (*posterior*) holes that carry the messages about some sensation *to* the grey matter in the brain or spinal cord.

Back (*posterior*) nerves carry news of sensation.

Front (*anterior*) nerves carry commands about movement.

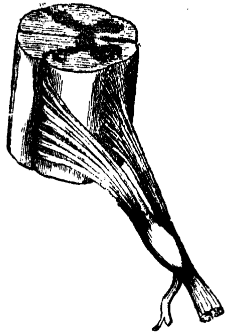


FIG. 34.—A PAIR OF NERVES ISSUING FROM THE SPINAL COLUMN. Messages go by the nerve which is on the left. Commands return by the nerve which is on the right of the picture.

Sometimes the carrying-to nerves are called sensory, and the carrying-from nerves are called motor. You will see why.

The other day a young American girl said that when she first came to England she put her hands on the bars of the fire, not knowing that they were hot enough to burn her, for in America they only use closed stoves.

"Do you know what happened?"

"Why, she was burned," you will answer.

Yes, certainly, her skin was burned; but let us follow what happened amid her miles of nerve pipes.

First the tiny nerves under the skin felt the heat and shrunk away shrivelled. Rapidly the carrying-to nerves (*posterior*) took up the news to the brain. There it was received and immediately acted on. The carrying-from nerves (*anterior*) carried commands to various places.

To the hands it sent the order—"Remove your fingers from the bars."

To the face—"Contort the features."

To the mouth and throat—"Cry for help."

To the feet and legs—"Step backwards."

To the eyes—"See that your dress has not caught fire."

All the news that the carrying-to nerves (*afferent posterior*) took was about sensation, and therefore they are often called sensory nerves. All the news that the carrying-from nerves (*efferent anterior*) took was about movement, therefore they are often called motor nerves.

CHAPTER XX

THE JOURNEY OF THE SENSATIONS

THE NERVES AND THEIR WORK

In the last chapter I told you that the spinal cord was made of both nerve fibres—carriers, and nerve cells—feeders. Both together they lie within the bony box of the spine, and do their respective work, the carriers being pale and white, the feeders being a pinkish grey in colour.

"Do they lie side by side all in a muddle?" asked a girl I was teaching. She was so tidy and prim herself that the idea of anything "in a muddle" was quite painful to her.

"No," I said; "indeed they do not. They lie in a pattern, the grey cells keeping to themselves and the white fibres occupying only exactly the room allotted to them."

Let us in imagination take one of the bones of the back-bone and look down into it. We should see a bit of the spinal cord, and we should find that it would look something like it is drawn in Fig. 34.

The grey matter—nerve cells—would be in this curious shape in the centre of the spinal cord; the white matter—nerve fibres—would be lying all around it. As you know, the white matter are the nerve fibres, the carriers, and the more gaily coloured (shown here though only as grey) are the nerves cells—feeders.

You will not have forgotten that the nerves go in pairs coming out and going into the back-bone.

Here is a picture which will show you these nerves as they appear coming from the spinal cord out from between the bones of the back-bone (*vertebræ*).

You will remember I told you that before we are able to move our arms or our legs something must go on in the brain cells and their tails in the brain. This is not always quite true, for there are plenty of cells and tails of cells

in the spinal cord, and sometimes the news of what has happened in different parts of the body does not get taken to the brain. The grey matter in the spinal cord receives it, stops the communication, and deals with the matter.

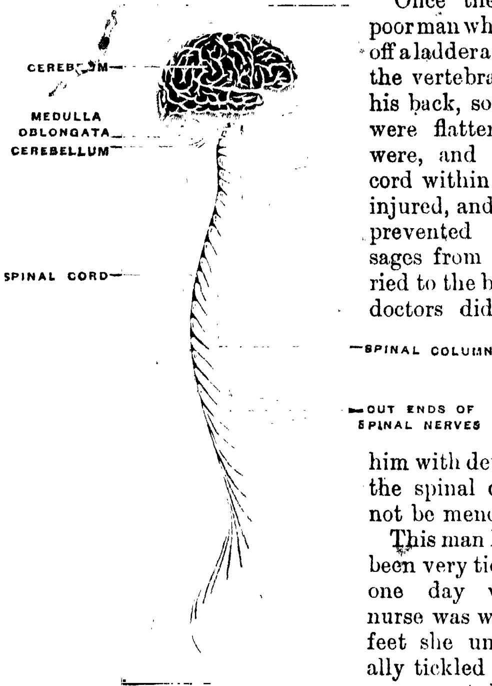


Fig. 35.—Diagrammatic View of Brain and Spinal Cord.

Once there was a poor man who fell down off a ladder and crushed the vertebral bones of his back, so that they were flattened, as it were, and the spinal cord within them was injured, and its injury prevented the messages from being carried to the brain. The doctors did all they could for him, and the good nurses attended him with devotion, but the spinal cord could not be mended.

This man had always been very ticklish, and one day when the nurse was washing his feet she unintentionally tickled them. In a moment he kicked out and wriggled, as people do who do not like having their feet touched. He himself did not know he had been tickled, or that he was kicking out. The sensory nerves took the news to the spinal cord, but as part of it was crushed, it could not carry the information to the brain. As you know the grey matter, or nerve cell, has the power to receive

the sensations and to command action, and some of that grey matter is in the spinal cord, arranged in the queer shape that you see in figure 37. So there was no need to go to the brain for orders. The grey nerve cells in the spinal cord were able to manage that small matter, and so from it, through the front nerve (*anterior*), went the command—

"Wriggle, or kick, to get away from the tickling."

But in the brain, and the brain only, is the seat of consciousness or knowledge, and there also dwells that wonderful part of us which is called our will, by which we can decide what to do, whether it be about a little thing, concerning "what we shall eat, or what we shall drink, or wherewithal we shall be clothed," or whether it be about a big thing, concerning our duty to those to whom everything is *due* from us, or about our nation's welfare, or our own part in that big warfare for all that is right against all that is evil.

In the spinal cord there is no consciousness, no will. Its grey matter can only take the sensations it receives, and reply accordingly; but if they go to the brain the will can command any action after thought has decided.

For instance, suppose you are in the room with your mother, or the dear baby. Mother perhaps has been poorly all day, and has just dropped off to sleep. A mischievous brother pinches you, or makes great fun. As your spinal cord is uninjured, the news gets to your brain. Your impulse is either to laugh or to speak out, but you remember that the little sleep may make mother's headache well, and so your will comes in and commands your motor nerves not to move.

Again and again goes the order down the spinal cord and through the front nerves (*anterior*), that the body is not to move and the laugh to be stifled. If the will has been practised often enough it will conquer, in spite of the grey matter in the spinal cord being ready, without any brain orders, to send back quite different instructions.

This is a little instance, but as you go on through life you will find many opportunities of seeing how the will should and can conquer what we call our **natural feelings**;

but you must practise it when you are young, or it will not be strong enough to do all it should do when you are older. The will, like the muscles, grows by use. "Disuse is death."

CHAPTER XXI

THE JOURNEY OF THE SENSATIONS

REFLEX ACTION

REFLEX action—what does that mean? Well, you learnt something about it in the last chapter, though not by the name of reflex action. Shortly, we mean by reflex action those actions that take place without the aid of the will or consciousness, which have their only home in the brain.

They are the actions about which the grey matter manages to receive information, and to give orders without further instruction from anywhere.

They are the actions which are done, as it were, by the little nerve centres, without the knowledge, and uncontrolled by the will, which dwells only in the brain in the head.

The grey matter which manages reflex action is not always in the spinal cord. If somebody's hand was suddenly held up as if to throw something at you, you would instinctively close your eyes. "Instinctively," I say, because you would close your eyes from instinct, and before your brain had had time to receive (*in its sensory portion*) the news that a blow was threatened, or to send (*by the motor nerves*) the command that the eyelids were to be drawn over the eye to preserve that wonderful little organ. No, the news never got to the sensory chamber of the brain; it only got as far as the nerve centres in the brain which have to do with the eye, and from there the reflex action took place which caused the eyelids to close.

If a child is very hungry, and sees something good to eat, his mouth waters. The idea entered the nerve

centre in the brain by the carrying-to (*afferent sensory*) nerve of his eye, but no order is carried back to the eye. Reflex action causes the carrying-from (*efferent motor*) nerves of his mouth to be set in motion, and their action causes the saliva to flow.

Choking is entirely a matter of reflex action. Some saliva or a little remnant of food goes down what is called the "wrong way." Unconsciously you will begin to cough and splutter. Reflex action is set up, the grey matter both receiving the news that the saliva or food is where it should not be, and giving the command that by coughing it should be evicted as an unwelcome tenant.

All that you have been learning about is a part of

The Brain and Back-bone System (*Cerebro-spinal*).

Now, before we finish this chapter, I must tell you that there are no less than twenty-four very important nerves. Not but that all and each is important, but these twelve pairs are specially so. They are called

The Skull Nerves (*Cranial*).

It is always easier to understand a difficult thing if you see it in a table, so I will make you one below this. From it you will see a little about each pair of nerves and what they have to do.

One pair carries to or from the brain all the messages and commands about—

1.	**Smelling, it is called** . . .	(*olfactory*).
2.	**Seeing,** „ . . .	(*optic*).
3. 4. 6.	**The movements of the eyes** . .	(*motores oculi*). (*trochlear*). (*abducens*).
8.	**Hearing, it is called**	(*auditory*).
9.	**Tasting,** „	(*glosso-pharyngeal*).
12.	**The movements of the tongue** . .	(*lingual*).
5.	**The feelings of the face; the movements of the jaws; the movements of the front of the tongue** . .	(*trigeminal*).
7.	**The movements of the face** . .	(*facial*).
10.	**The throat chamber; the lungs; liver; stomach; and heart** . .	(*pneumogastric*).
11.	**Muscles of the neck**	(*spinal accessory*).

These nerves are, as I said, very important. If they

are injured, the use of the part from whence they come is much lessened.

"Yes, I fear he is hopelessly blind," was said to the mother of a young and clever man.

"Can nothing be done?" she asked, as she sadly saw how her son's career must be blighted by such a loss.

"Nothing, I am sorry to say," replied the oculist; "his optic nerves are quite destroyed."

"And can no art or skill repair them?"

"No, indeed, they are more delicate than anything human art can make; more complicated than our ingenuity can devise," he replied.

He would have spoken truly had he said the same thing of all the other eleven pairs of the skull nerves (*cranial*), for they are all alike in being beautiful and exactly adapted to their purposes.

CHAPTER XXII

THE JOURNEY OF THE SENSATIONS

THE SYMPATHETIC SYSTEM

"ANOTHER chapter on Nerves; what a lot there are!" I fancy I hear you say. Yes, and there is yet another group of nerves about which you must learn. It is called

The Chain and Knot, or Sympathetic System.

Here is a picture which will help you to understand something about it. By looking at it you will see that nerves go down the body. On each side of the backbone is a sort of chain. Every now and then there is an extra big group or cluster of them, and you will notice that they are especially numerous around

The Heart. The Stomach. The Lungs.

Connected with each of the knots or groups there are a set of carrying-to (*sensory afferent*) nerves, and a set of carrying-from (*motor efferent*) nerves, so that each of these

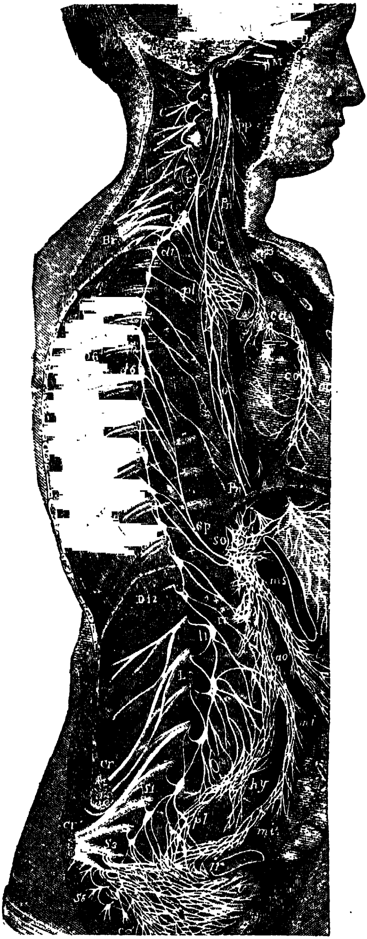


Fig. 36.—The Sympathetic Chain of the Right Side, showing its connection with the Principal Cerebro-Spinal Nerves.

knots can receive news and transmit orders just in the same way as the grey matter of the brain or spinal cord is enabled to do.

"In what way, then," you may ask, "does the Sympathetic system differ from that of the spinal nerves?"

"Not much in **what** it does, a great deal in **where** it does it," would be the answer.

The work of the Sympathetic system controls and influences only

The Circulation, *the Heart's work.*

The Digestion, *the Stomach's work.*

The Respiration, *the Lungs' work.*

We can liken the nervous system as a whole to a family consisting of father, mother, son and daughter. The brain, or rather the great brain, we will imagine to be the father of the family and the head of the

household. To him come all the important matters, and he is asked what he thinks about these things, and what he wills to do about them. He is much engrossed and not very strong, and therefore his thoughtful wife, the *medulla oblongata*, saves him all she can, and carries on all the routine affairs of the household herself. But in this partnership each parent has a helper. Father Brain decides on all that has to do with the outside of the house, and who shall be welcomed as friends, who avoided as enemies. But in carrying out his commands he depends on his son, the system of spinal nerves, which take the messages to the muscles and from the skin, the eye, the ear, the nose, and the tongue; and just as Father Brain would be powerless without his son to carry messages, so Mrs. Medulla, who has the housekeeping to do, would be quite lost without her dapper daughter, Miss Sympathetic, who, although she never aspires to take any part in public life, is a quite necessary part of the household, as she is constantly taking messages between Mrs. Medulla and her servants, telling the stomach how to deal with the food, the heart and blood-vessels how to distribute the nutriment derived from the food, and the muscles of respiration how to keep the house properly ventilated.

The sympathetic system of nerve knots lies, as I have said, on either side of the back-bone, and is connected with the spinal cord by nerves of both the sensory and motor kinds, so that, if necessary, news from it may be sent to the spinal cord, and by the spinal cord to the medulla, or even higher up still, to the big brain itself, and this is done if anything goes wrong with either of these departments.

For instance, we know that if any one says anything unkind or rude to us we feel hot all over and "blush." The words enter our ears, and are carried by their nerves to the brain. They cause thoughts. The impression is received by the spinal cord, and passed on by the spinal cord to the sympathetic system. For a moment or two the nerves are paralysed or become limp, as it were; their control over the blood-vessels has

gone, and the blood gathers in the vessels and makes the skin red.

In a similar way a great sorrow will upset a person's digestion, because it will affect the nerves, which will act through the sympathetic system.

In many ways it is known that the imagined daughter —Miss Sympathetic—can have easy access even to Father Brain himself, in case of anything unusual occurring: for though we are not generally conscious of our heart beating or of the blood flowing by, if they go on in the usual way, yet should the heart beat too fast we know that we have palpitation, or should the blood stop we feel without looking that we are blushing. But, on the other hand, Father Brain has not absolute power over Miss Sympathetic's departments, for however much we may will, we cannot make our blood go slower, or decide what we shall or shall not digest.

You must not, however, think that the sympathetic system is independent of the spinal cord. No, it is no more independent than the spinal nerves themselves are, for within the bony box of the spine are a special set of nerve cells from which the sympathetic fibres proceed; but their exact relation is too difficult and complicated for you to understand until your brain cells are bigger and their tails more vigorous, but if you work hard and conscientiously they will certainly become so.

CHAPTER XXIII

THE JOURNEY OF THE FOOD

THE TONGUE

THE tongue is divided into three parts:—

I. **The Root.** II. **The Body.** III. **The Tip.**

The **root** of the tongue is that part which is farthest from the entrance to the mouth, and which joins it to the throat. The **body** of the tongue is the main portion

of that "unruly member." The **tip** of the tongue is the flexible end which is nearest to the front teeth. The tongue has three uses:—

1. **It rolls the food about when it is being chewed.**
2. **It helps people to speak.**
3. **It is the organ of the sense of taste.**

The tongue itself is almost entirely made of muscles. You will all remember the lesson about muscles, and how I told you they were bundles, or separate masses of flesh, which have the power of stretching or becoming long, or contracting and becoming short, like so many pieces of elastic put side by side, only some muscles are a hundred times smaller than any bit of elastic that any of us have ever seen.

Well! the tongue is made of muscles, which are ever ready to be busy in moving the food about the mouth. It takes the different sorts of food to the different sorts of teeth that are needed to crush, grind, or tear it. It rolls it round and round the mouth, and if by chance a bit of bone or hard food gets into the mouth, we all know how the tongue will move and wriggle until it divides it from the other food, and brings it, by the aid of the tip, towards the lips, when the hand can easily reach and remove it.

Perhaps more than most muscles those of the tongue work hard, especially if people talk a good deal; but as they are very strong, they do not often tire. Next time you eat it will be well for you to try and notice how much and how rapidly the tongue moves about, and then think how many and how varied the muscles must be to enable it to move in so many different ways, so quickly and so strongly.

In the chapter on the brain you heard something about the special nerves (ninth and the twelfth) that have to do with the taste and control of the tongue; and then, children, as you think of all these wonders I hope the thought will enter into you that such marvellous mechanism should be only put in motion to help on all that is good and pure. To use the tongue to speak that which

is false or unclean, or to ask it to aid to swallow that which injures the body, or makes the brain unbalanced, is to act contrary to the laws of the Creator Who has had us taught that lies create evil and pain, and that woe follows indulgence in strong drink, for it "shall be bitter to them that drink it."

Here is a picture of the tongue.

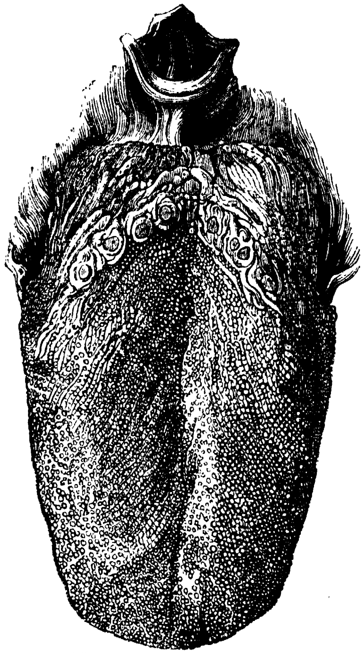


FIG. 37.—THE UPPER SURFACE OF THE HUMAN TONGUE.

As you know, all the parts of the body that you can see are covered with skin. In some parts the skin is soft and fine, in other parts it is coarser. Besides the outer skin, which you can see, there is another skin which lines the passage through which the food goes (*alimentary*

canal), as well as certain other parts of the body. It is called

The wet skin (*mucous membrane*).

You can see this wet skin (*mucous membrane*) in the mouth, and on and around the tongue. If some child now were to open the mouth, you would see how red it looked inside, how much more bright and rosy the tongue looked than the forehead does; and yet the blood-vessels run into the flesh of the forehead, to keep it alive and healthy, as they do in the tongue.

"Why, then, is one white and the other red?"

Because the wet skin (*mucous membrane*) which covers the tongue is so much thinner than the outside skin that it allows all the red blood to show through it, and that is why the tongue looks red. Under the tongue the mucous membrane is smooth and thin and soft, but on the upper part of the tongue it is quite different.

CHAPTER XXIV

THE JOURNEY OF THE FOOD

THE HILLOCKS ON THE TONGUE

Look at the picture again, and then take it in turn to look at each other's tongues and compare what you see with the picture. In front you see it is rough with "hillocks"—some, fine like threads, others more like mushrooms. Now, just as the eye is the "organ" or part of the body with which we see, so these hillocks are the parts of the body with which we taste, and the hillocks are of three kinds:—

1. **The Thread Hillocks** (*Filiform Papillæ*).
2. **The Mushroom Hillocks** (*Fungiform Papillæ*).
3. **The Rampart Hillocks** (*Circumvallate Papillæ*).

Those hillocks in the front of the tongue taste both salt and sweet things. You have often heard people say—"Ah! she has such a sweet tooth."

FIG. 38.—THE THREAD HILLOCKS.

This sounds as if the tooth had the power of tasting, but this is not the case. It is those little hillocks which have that power; and if any one has a "sweet tooth," it means that he has more of these hillocks on his tongue than most other people.

If you could suppose that some one had all these hillocks on his tongue destroyed, he would not be able to taste salt. You might give him a whole spoonful, and yet it would only seem to him like a tasteless powder in his mouth. Did you ever give a dog a lump of salt just for fun, to tease him? He will put it out so hurriedly, especially trying to get it off the tip of his tongue, although it might have gone quite into his mouth and on to the back of his tongue. That is because most of the thread hillocks (*filiform papillæ*) are at the tip of the tongue, and so he tastes the salt most just there.

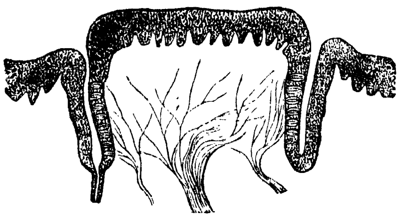


FIG. 39.—A RAMPART HILLOCK, SHOWING ALSO THE DISTRIBUTION OF NERVE FIBRES.

If you look far back in the tongue you will see some very large hillocks arranged in the form of a V. These are—

The Rampart Hillocks (*Circumvallate Papillæ*).

Here is a picture of one, and by it you will see that the reason it is called the rampart hillock is because it is shaped like a wall or rampart.

There is a limit to the number of this kind of hillock.

Some people have seven, some ten, on their tongues. If you turn to the picture on page 82 you will see them quite plainly. They are arranged at the back of the tongue in the shape of the letter V.

To them is given the power of tasting bitter things, and you may have noticed, if ever you have taken quinine medicine, how you do not seem to taste it till it has all but gone down your throat. Bitter as it is, it passed the thread hillocks (*filiform papillæ*) without affecting them; it slipped over the mushroom hillocks (*fungiform papillæ*), and they took no notice; but when it reached the rampart hillocks (*circumvallate papillæ*), they were influenced by it. The little nerves in them, which you will see in the picture, carried the news to the brain that they had been touched by something bitter, and the command probably came from it to make an ugly grimace.

Why we taste and how we taste is not yet known fully, but we do know that things to be tasted have to pass right through the wet skin (*mucous membrane*) of the tongue, and really touch something in the little hillocks before the nerves will take the news to the brain.

You know that some people like dainty cooking and good things to eat, while other persons do not care much what sort of food they have so long as they have enough.

The reason of this very often is that the skin of the tongue (*mucous membrane*) is finer on some persons' tongues, and the nerves in the hillocks more numerous, than is the case with others. Thus the flavour gets more rapidly through the more delicate skin, and small differences are more quickly noted and told to the brain, for even in these little hillocks (*papillæ*) there are some carrier nerves to do nothing else but take news to the brain.

In the matter of taste, as in other things, "use is development," and the men whose business it is to spend all their days in tasting different sorts of tea, as the great chests arrive from India, China, and Ceylon, get such a power of delicate discernment that they can find out twenty tastes in their tiny cups where you and I could not find out any difference.

CHAPTER XXV

THE JOURNEY OF THE FOOD

WHAT IS THE MUCOUS MEMBRANE?—WHAT ARE GLANDS?

PERHAPS some of my young readers will have noticed that in the last lesson I used a long word, for which I could not find an easy meaning, and which I did not explain. Well, there is so much to say about that long word and wonderful thing,

The Mucous Membrane,

that if we had stopped to talk about it we should not, that day, have been able to learn about the tongue; so it seemed best to leave the long word to be explained in the fresh chapter to be studied to-day. Let each child touch his or her lips. Now the skin is being touched. Let the finger go past the lips towards the mouth, until it touches the inside of the lips, which is soft and wet. Now the mucous membrane is being touched. It is a very fine soft sort of skin, which lines all the parts that have to do with the food, and about which we are now going to speak. It is always wet or moist, and the fluid which keeps it wet is called **mucus**; so it might almost be said that the meaning of the long word, mucous membrane, is wet skin. It is made by the help of some tiny helpmates called

The Glands.

What are they? **Glands** are organs, or instruments, which have the power of calling from the blood that which they want. Here is a picture of three sorts of glands.

That marked 1 is, as you will see, a tiny narrow pit. That marked 2 looks like a small round bag with a narrow neck, while the 3rd is a twisted coil not unlike the sweat

gland, about which you heard when we talked of the skin. There are many other sorts of glands, but they are too

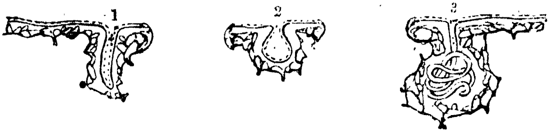


FIG. 40.—SIMPLE SECRETING GLANDS.
1. Straight tube. 2. Sac. 3. Coiled tube.

difficult for you to understand, for you are only learning a little, and *very* little, about this wonderful body of yours.

"I have finished physiology and anatomy," a girl of sixteen once said to me.

"Finished them?" said I in astonishment, for no one, not even Professor Huxley himself, has "finished" physiology and anatomy. But what she meant was that, having read and more or less committed to memory the books set for her to study, she had done all she meant to do, and felt she had finished with the science. I should be sorry if you put down this little book feeling you "knew all about anatomy." Sometimes you will find pictures of parts of the body about which there is little or no explanation, so that you may know the truth, which is that there is

"A beyond and a yet beyond"

to every single thing that exists. Broadly speaking, there are two distinct sorts of glands. They are called—

1. **The Preparing Glands** (*Secreting*).
2. **The Separating Glands** (*Excreting*).

The preparing gland (*secreting*) is so called because it takes out of the blood certain materials which are already in it, and with them it prepares a new and quite different material, which it puts aside or stores for some other use.

You can imagine that a preparing gland (*secreting*) is like a careful housewife who goes out on to the wide open common and gets sweet herbs out of it. Many other people have seen and passed those herbs. It is

only the good house-mother who picks them and brings them in, and makes health-giving drinks and sweet-smelling medicines from them. These she stores carefully away till the need arises for them, and then there they are, all ready for use.

In like manner the preparing (*secreting*) glands work, take from the blood those materials which have been let pass by other organs, and make them into another and a fresh material to be put to good uses.

The separating gland (*excreting*) has a different use. Like the other sort of gland, it takes materials from the blood, but when it has got them, or separated them, it does not use them to make anything else. No! it merely separates them. If the preparing gland (*secreting*) can be likened to the careful house-mother, it can be said of the separating gland (*excreting*) that it does the work of the scavenger. From the blood it takes the materials that are not wanted, and evicts them out of the body. If you recall the facts about the sweat glands, with their ducts, you will be able to understand that they are separating (*excreting*) glands.

The finger that you have put into your mouth will have told you that the mucous membrane which lines it and covers the tongue is wet. What makes it wet?

There are two causes. First, the whole of the mucous membrane is full of tiny glands, such as we have been speaking of, which have for their work the calling forth of a watery fluid from the blood and emptying it out, so that the mucous membrane may be kept wet. Secondly, there are in the mouth some special glands, called

The Spittle-making Glands (*Salivary*).

They are preparing glands (*secreting*), and their work is to prepare the spittle (*saliva*). Spittle is very useful. It keeps the mouth moist, and it also aids the food to digest. Indeed, there are lots of things which are good for food which we could not eat if the spittle were not there to help. I will only tell you of the three spittle-making glands (*salivary*)—

1. **Near-the-ear Glands** (*Parotid*).
2. **Under-the-jaw Glands** (*Submaxillary*).
3. **Under-the-tongue Glands** (*Sublingual*).

There are two of each of these glands, one on the right side, one on the left side of the mouth. We will speak first of—

1. The Near-the-ear Glands (*Parotid*).

They, as their name shows, are placed near the ear, just where the jaw moves up and down. They are the largest of the three sets of glands, and just now they are pouring the saliva into the mouth of the child who has read—or your teacher who has explained—the lesson to you, for it is to these and the other glands that people who talk owe the moisture that enables them to speak.

2. The Under-the-jaw Glands (*Submaxillary*).

The openings (*ducts*) from these glands are under the tongue, the glands themselves being about an inch long, and situated one under each jaw.

3. The Under-the-tongue Glands (*Sublingual*).

are easily to be seen. The next time you look in the glass, if you open your mouth and put your tongue over your upper lip you will see them. One gland is on either side of the little skin bridge that joins the tongue to the lower jaw.

From these three pairs of glands there pours forth a great quantity of the liquid called spittle (*saliva*). It is difficult to decide how much is made in the day, but a learned man called Dalton has made a calculation, from which he tells us that an ordinary healthy person, eating a fair amount of both sorts of food, will secrete from one to two pounds a day. All this saliva has three uses—

1. **To make the food wet.**
2. **To make it stick together.**
3. **To turn into sugar the starch of the food.**

"I could not shout, my mouth was so dry," was said

by a man who, when out shooting in India, had strayed away from his companions and suddenly came face to face with a huge man-eating tiger. What he said was scientifically true. His mouth was dry because the shock had paralysed the nerves that keep guard over the gland ducts, and the spittle could not get out into the mouth.

"My mouth watered," is an expression used by people who care a great deal about good things to eat, or by those who are very hungry. Now you will know what that expression means. The salivary glands drew from the blood and prepared some spittle (*saliva*), which it poured through its ducts near the tip of the tongue, so as to be all ready to meet and help the food when it was put into the mouth.

Starch is found in beans, peas, potatoes, rice, corn, and maize. Thus we see that directly the food goes into the mouth it begins the changes that have to go on till it becomes part of the human body.

"She is small, but then she has not been long born," was the comfort given to a mother who was anxious because her child was so small.

"Not long born, ma'am! Why, she is six months old!" explained the woman.

"What do you feed her on?" was next asked.

"Milk, corn flour, or a little ground rice pudding, and a bit of mashed potatoes sometimes."

"No wonder she is not well grown, then," returned her friend, "because all these foods are starchy. The spittle glands (*salivary*) do not begin to work until a child is five or six months old, and it is they who begin the work of turning starchy foods into blood."

CHAPTER XXVI

THE JOURNEY OF THE FOOD

THE TEETH

All the girls and boys who will read this book will be above seven years old, so they will all have got their second or permanent teeth.

The first teeth, or milk teeth, as they are sometimes called, come when the baby is between six months and a year old; but they have no roots, and drop out when the little one is about five years of age. The number of the milk teeth is twenty, but when they disappear twenty-eight permanent teeth take their place and do all the duty of chewing and grinding until the person is about twenty-one years old, when four more teeth are cut. These are sometimes called wisdom teeth, because they do not come out until, it is hoped, their owners have learnt wisdom. Here is a picture of a tooth.

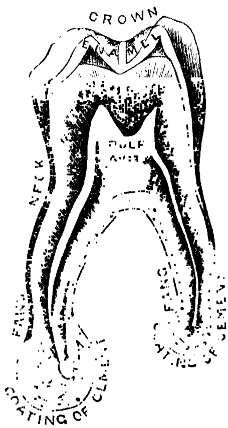


Fig. 41.—Section of a Tooth.

You will see that each tooth consists of three parts :—

1. The Root or Fang; 2. The Neck; 3. The Crown.

Teeth look something like bones, but they are not made of the same material, and in other ways are not of the same structure. They chiefly consist of a substance called

Dentine,

which is in itself somewhat soft, and soon decays if it is

at all exposed to the air. Over this is another substance called

Enamel.

It is very hard, brittle, and white, and has no blood-vessels. If, therefore, it becomes chipped or damaged, it does not grow again, and the softer dentine, without its coat of harder enamel, soon falls ill, decays, or rots.

If you look at the picture you will see that before the two fangs divide, and below the enamel and dentine, is a cavity called

The Pulp Cavity, which is filled with **Tooth Pulp.**

Tooth pulp is a mass of nerves and blood-vessels.

Each tooth, then, not only consists of three parts, but each one is composed of three different substances, namely,

Dentine, Enamel, Tooth Pulp.

The enamel is the coat or sheath, and it is the part that we should be most careful to preserve from injury or decay; for if you break the enamel and let the air into the dentine, it decays. While it is decaying we feel little or no pain, but directly even a little hole is made right through the dentine, which allows the air or spittle or food to get into the pulp cavity, the pain begins, because the nerve is reached, for, as you have heard, it is the nerves that have the wonderful power of carrying feelings of pain or pleasure to the brain.

The enamel can be easily broken, scratched, or damaged. Cracking nuts, or biting hard things, or thread, will chip it; while sweet stuff, or goodies, make an acid that sinks through the enamel, hard as it is, and gets at it from the inside.

It is very important to have good teeth, and to keep them clean and healthy.

"She would be very pretty, only she has such bad teeth," is more often heard of a girl than it should be; or—

"Yes, he's a nice boy, but he would be nicer if he used his tooth-brush," is a verdict given sometimes on boys. This is a pity, for a tooth-brush only costs a few pence, and to brush or clean the teeth merely costs a little trouble

and a few minutes, and all of these are well expended if they keep the teeth clean and from decay.

When food is being taken little bits sometimes stick to the teeth, or remain clinging to the gums. This is uncomfortable, but sometimes small pieces get wedged in between the teeth so that they are not noticed, and then the aid of the tooth-brush is required to find them out and dislodge them. If any food is allowed to remain round the gums or teeth it decays and gives out a gas which in time injures the enamel and so the tooth.

Children sometimes cut their teeth with much pain, and sometimes with illness. This is more especially the case with children in large airless towns, than when they are living in the country, because the doctors say that the nerves of town-bred children are weaker and more easily upset than those of children who have always breathed the purer air of the country.

"Ah! poor little dear," we hear kind mothers and nurses say, "he is trying to cut his teeth," by which they mean that the new teeth are being pushed outward through the gum.

CHAPTER XXVII

THE JOURNEY OF THE FOOD

THE FOUR SORTS OF TEETH

In the last chapter we talked of teeth in general, and you learnt something of their material and function. This chapter will be about the different sorts of teeth and their various works. There are four sorts of teeth—

1.	**The Biters** (*Incisors*), **of which there are** .	**8**
2.	**The Tearers or Dog Teeth** (*Canine*), **of which there are**	**4**
3.	**The Chewers** (*Bicuspids*), **of which there are**	**8**
4.	**The Grinders** (*Molars*), **of which there are** .	**12**
		32

There are thirty-two in all, but, while you are children, you will only have twenty-eight.

If you live to be over twenty-one, and cut four wisdom teeth, you will have the thirty-two, but now you have only eight grinders (*molars*) instead of the final number twelve.

We will take each of these different sorts of teeth, and try both to learn and to remember something about each.

Here is a picture to help you.

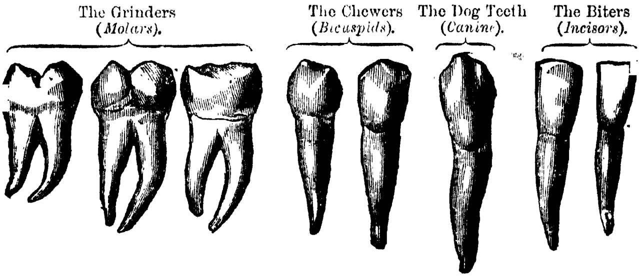


FIG. 42.—THE TEETH CLASSIFIED.

This figure shows the eight teeth in each half of the upper and lower jaw. Hence, although there are but three molars, two bicuspids, one canine, and two incisors in the figure, there are actually four times as many of each in the whole set of teeth.

1. **The Biters** (*Incisors*) are in the front of the mouth, four in the top and four in the bottom jaw.

You know, if you are going to bite a bit of bread, you naturally use those teeth; and if next time you are at tea you take one bite out of a slice of bread, and then look at the bit that is left, you will see the marks of all the eight biters (*incisors*) left clearly on it.

They are sharp chisel sort of teeth, and have the power of biting and gnawing. They are large and well developed in such animals as rats, rabbits, or squirrels, who use them much in gnawing their food. These are the teeth that are shown on the right side of the plate.

2. **The Dog Teeth** (*Canine*), of which there are four, are the next to be considered. They are placed, one on

each side of the biters (*incisors*). Their business is to tear the meat food. It is not easy to see them in the mouth of a human being, but they are very prominent among the teeth of cats and dogs and tigers.

Once I had a dog who was in all ways a nice character, with one exception. He was very fond of biting the naked legs of little boys and girls. He used to dart after them, bounding and barking as if in high good-humour. The children used to run in play with him and laugh at his fun, when all in a moment his four biters (*incisors*) were buried in their legs. Then there was fear and crying and pain.

We did all we could to break Rex of this habit, but all unavailingly, so at last I told him that if he again bit a child I should have to send him to the dentist to have his tearers or dog (*canine*) teeth out.

He was so sensible that he almost seemed to understand, but the fat, bare legs of a little chap of six proved too much for him one day and he bit the boy. So to the dentist went Rex, who first of all put him under chloroform, which so affects the carrying-to (*afferent*) nerves that for a time they cannot deliver news of pain to the brain. Then while he was quite unconscious of suffering he filed down his four canine teeth until they were on the same level as the biters (*incisors*) and the chewers (*bicuspids*).

Poor Rex! he seemed sorry to lose his power of tearing his meat, and we had to feed him on sop afterwards, but anyhow the children were left in peace.

3. **The Chewers** (*Bicuspids*), of which there are eight, come next to the tearers or dog (*canine*) teeth.

Bi means two, and these teeth get their name because they have two caps or ridges on their tops which enable them to chew the food. If you think a moment you will see that a thing with an unequal surface will be able to smash and so reduce something else to pulp more quickly than if the surface were flat and smooth. This is why the eight chewers (*bicupsids*) have two ridges.

4. **The Grinders** (*Molars*). Eight you have now. Twelve your teacher has, because grown people cut four

more molars when they get their wisdom teeth. Wisdom teeth, however, do not often last very long, and indeed eight grinders (*molars*) are quite equal to the work that they have to do for a human being.

They are the true grinders, and their work is to grind the carbonaceous food that is put into the mouth. They are to be seen at the extreme left of the picture. They have four or five ridges, and as the food is moved these ridges grind it into fine pieces. If you look into the mouth of a cow, or a horse, you will see how large and strong the molars are, for as they live on corn or grass, they need teeth to do a great deal of grinding or mill work. Just as the tearers or dog teeth (*canine*) can be best seen in a dog, so the grinders (*molars*) can be best seen by watching a cow. You will notice how she licks up the hay or wet grass into her mouth with her long pliable muscular tongue, and then grinds, and grinds, and grinds it with her grinders (*molars*) until it is a wet brown or green mash.

All the four sorts of teeth work when food is put into the mouth; but, as a rule, people do not make the teeth do all they ought to do. The food is too often swallowed before the teeth and the spittle have done their work, and this causes pain, discomfort, and illness.

"If one person neglects his work it means that another person must labour more." This law works in the body of each of us as it does in the larger world. If the food is not chewed enough, it gives the stomach and its servants more work to to, and they get tired and ill.

Meat should be chewed thirty-two times before it is allowed to leave the teeth workshop. Bread need not be ground quite so often, but all food should be kept in the mouth long enough for it to get soft and pulpy—and not only moist, but, as it were, thin and liquid by the action of the spittle or saliva.

CHAPTER XXVIII

THE JOURNEY OF THE FOOD

THE UVULA—THE THROAT CHAMBER OR PHARYNX—THE GULLET OR ŒSOPHAGUS

To-day we will take a mouthful of food, and follow it on its journey till it reaches the stomach.

First it will be rolled by the tongue, then it will be bitten, torn, chewed, and ground by the teeth. From the mouth glands the spittle (*saliva*) will be poured upon it, and at last it will be ready to leave the mouth and begin its journey towards the stomach.

If you take a looking-glass, and open your mouth *wide*, and say "Ah-h-h-h-h!" you will be able to see a little bit of flesh hanging from the top of the mouth, pink and soft, which jumps up and down very quickly as the sound of "Ah-h-h-h!" comes out of your mouth. That bit of flesh is called

The Uvula.

The hard palate is the roof of the mouth. The soft palate is the continuation of the hard palate, and lies at the back of the mouth. At its very end it is called the uvula, which as the food reaches it will jump up and let it pass, and then the food will find itself in a kind of chamber or room called

The Throat Chamber (*Pharynx*).

There are five openings into it.

1. 1 from the ear (*Eustachian tube*).
2. 1 from the nose (*nasal passage*).
3. 1 into the lungs (*larynx*).
4. 1 from the mouth.
5. 1 to the stomach.

I suppose it has happened to everybody in the room, some time or other, to feel choked. How disagreeable it

is when a mouthful goes the "wrong way." How rude it seems when you splutter and cough, and how sorry and vexed people around you are, according to whether they are kind or unsympathetic.

What happens when a mouthful goes "the wrong way" is that it goes out of the throat chamber (*pharynx*) by the

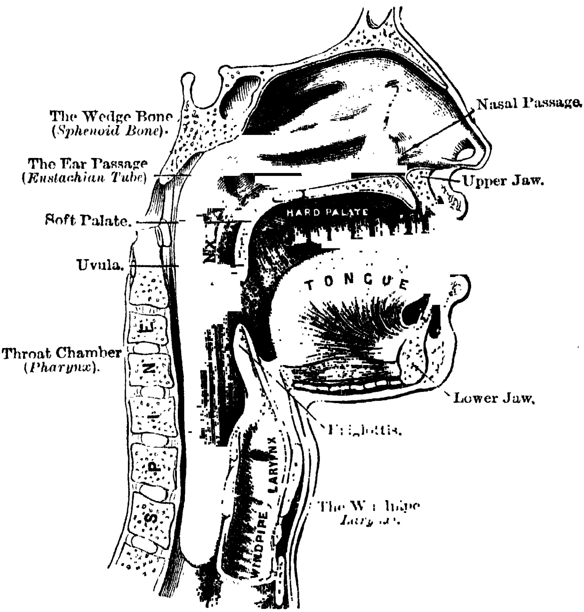


FIG. 43.—SHOWING THE POSITIONS OF THE UVULA, THE HARD AND SOFT PALATES, AND THE PHARYNX.

wrong door. It takes the road to the lungs, down which only the air is intended to go, rather than the road to the stomach, by which the food should travel. If you have been present when a person choked, you will have seen how sometimes the food or tea was spurted out of the mouth or nose. That is because it has been jerked up

out of the road to the lungs so vigorously that it had to find an exit somehow, and so it got out by the nose passage as well as by the mouth.

As you can imagine, it is of the utmost importance that the food should not go either into the nose, the ears, or the lungs, so in the throat chamber (*pharynx*) there are some marvellous and beautiful arrangements to help the food to go into the one place that does want it, namely, the stomach. But these arrangements have more to do with the lungs than the stomach, so we will let the food pass by now, and I will tell you about them when we speak of the lungs.

Interesting as the throat chamber (*pharynx*) is, we must not linger over it any longer than the bit of food must linger in it. If we had time now we might explore the passage which leads from this roomy throat-chamber to the nose. Every one knows that if he has a cold, the water and secretion seem to run down from the nose into the throat. If you look at the picture you will see exactly how this happens.

Later you will also hear of the tube that goes from the throat to the ear, and which bears the long name of Eustachian; of this also we could learn more if we could linger, but we must hurry after the mouthful of bread, which by this time has left the pharynx and entered

The Gullet (*Œsophagus*).

This is a kind of tube like a very narrow stocking, about nine inches long. It is easily tickled or influenced. Directly it feels the food it allows it to pass, and then immediately closes behind it and pushes it down. The food goes on a little way, say about an inch, and then that inch of gullet closes up behind it, and so the food has no choice but to go on till it reaches the stomach.

The gullet (*œsophagus*) has three coats—

1. **The outer coat** (*muscular*); 2. **The inner coat** (*mucous*); 3. **The middle coat** (*connective*).

I am always glad when the names of the body parts about which you learn are easy, and these gullet-coat

names will not be a difficulty, and all the less so because these names express their uses and construction.

1. **The Outer Coat** (*Muscular*) is made of involuntary muscle fibres, some going up and down, some going round the tube. It is those that go round the tube which force the food onwards and which enable us to eat or drink while lying down. Perhaps you thought that the water you drank ran down, or the food you ate tumbled into the stomach. People say, "The food slipped down the throat," but this is not the case. Food does not slip down. No! Each sip we drink and each mouthful we eat is pushed down by the outer coat (*muscular*) of the gullet (*œsophagus*). Next time you see a horse drinking in the village pond or the city trough, notice his position. You will see that the water has to go up hill as he stoops over to get it. It is those muscles that grasp it or push it onwards, whether up hill or down making no difference.

2. **The Inner Coat** (*Mucous*) is, as its name tells, a coat with many glands which secrete mucus. It is not smooth, as in the inside of the mouth, but is all crumpled up in folds. By this plan the gullet gets a longer lining than would be possible if the lining were smooth, and so, as every bit of it has many wet mucous glands, much more mucus is poured into it. This it needs to keep it soft and wet, and to enable the food to pass through it easily.

3. **The Middle Coat** (*Connective*) is neither muscular nor mucous. To it is given merely the duty of connecting the other two coats together, without letting them ever touch each other.

Did you ever swallow a button or a pin, or something that you wished you had not swallowed? Directly it has gone you want to get it back, but you cannot, for the gullet (*œsophagus*) has shut up—or contracted—and will not let it return.

The gullet is the narrowest part of those pipes which carry the food, and this being so is another reason why the teeth should be well used. They should be made to do their own work and chew the food, so that none should be sent down the gullet until it is ground small enough

to pass through it easily. And yet the mouthfuls should not be too small.

"I can't take the pill," a child said in plaintive tones. "Nonsense," replied his mother; "you can if you try." "I really can't; I have tried," said the little fellow; and he was probably right, as you will now understand, because you know something about the coats of the gullet. The object to be swallowed must be large enough to touch both sides of the inner coat (*mucous*), or else the middle coat (*connective*) will not feel it and be able to tell the outer coat (*muscular*) to contract and push down whatever it is that has to be sent to the stomach.

Some people wrap up their pills in bread, so as to make them large enough to touch each side of the gullet, while others float them down in water.

When I was a little girl I recollect hearing my grandfather tell a tale. He said that one day as he was passing the alehouse in the village where we lived he heard a great noise. Men spoke with loud voices, but they were not quarrelling. Fear was in their tones, and he heard a woman's voice begging that the doctor should be immediately sent for. My grandfather was not a doctor, but he thought he might help, and so he entered the inn. There he saw a sad sight—a man sitting on a chair, black in the face, and struggling for breath. A dozen voices soon told the cause of the man's condition.

"He bet," they said, "that he could swallow a whole potato, and it has stuck in his throat."

There was no time to lose if the man's life was to be saved; so my grandfather, who was well known to all in the village, did not wait for any one's permission, but seized a fork and put it down the man's throat. It soon reached the potato, which was firmly wedged, half in the throat-chamber (*pharynx*), half in the gullet (*œsophagus*).

You will see how the man's life was in danger: the potato covered up and closed the passage leading to the lungs, so that no air could go into them or come from them; and it was so big that it had stretched the muscular rings which go round the gullet so wide that they could not easily contract again. The fork reached

the potato, and then, said my grandfather, in describing it, "I gave it a twist, and that divided the potato into bits which the foolish fellow was able to swallow." You see, when the pieces were small enough, the outer coat (*muscular*) of the gullet was able to grasp and push them downwards.

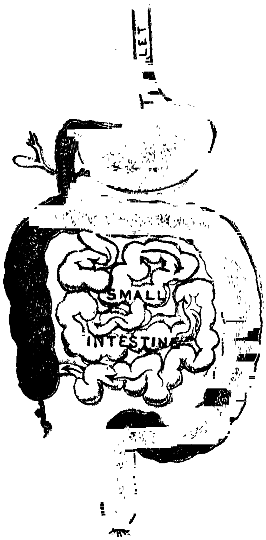


FIG. 44. — SHOWING THE JOURNEY OF THE FOOD— THE ALIMENTARY CANAL.

We have followed a mouthful while it travelled

> Out of the mouth,
> Past the uvula,
> Into the pharynx,
> Out of the pharynx,
> Into the gullet,
> Out of the gullet

The next chapter must be reserved to recount its further adventures in the stomach, right through

The Alimentary Canal,

which is the name given to the long pipe through which the food passes in order that it may be digested. Many people who have not learnt even such simple anatomy as this little book teaches have thought that the whole process of digestion goes on in the stomach, but this is not the case.

CHAPTER XXIX

THE JOURNEY OF THE FOOD

THE STOMACH—ITS COATS AND ITS GLANDS

In the last chapter we brought the food from the mouth to the lower end of the gullet (*œsophagus*), and left it just as it was, all ready to enter the stomach. The gateway or door by which it enters that important place is called

The Stomach Door (*Cardiac Orifice*).

Through this doorway the mouthful of food enters, and immediately finds itself in a big bag, shaped something like both a pear and a carrot, and not much like either. This bag is called

The Stomach,

and it has four coats. Three of them are exactly like the coats of the gullet (*œsophagus*), with exactly the same duties.

The Inner Coat (*Mucous Gland*), **The Outer Coat** (*Muscular*), **The Middle Coat** (*Connective*).

The fourth stomach coat is called

The Over-All Coat (*Peritoneum*).

To this is given a new work, that of secreting a fluid which you may call

Whey (*Serum*).

This fluid or serum is very necessary, for the different parts of the body are packed quite close to one another. It would never do for them to stick together or to become hard and dry, for then they would run the risk of cracking or scratching each other. So around most of the organs is placed a secreting over-all coat, called different names in

different parts of the body, which is kept constantly at work, in making the watery fluid which enables the various parts to lie together or move without hurting each other.

When the food enters the stomach it is not allowed any time to rest, for directly it is within the bag the work begins that is to turn the meat, and bread and butter, and potatoes into something else.

The work of **the outer coat** (*muscular*) is similar to the work of the same coat when it is round the gullet (*œsophagus*). That duty is to keep the food moving.

But the stomach being of a different shape from the gullet, the outer coat (*muscular*) is somewhat different. It is, indeed, a little complicated, but it is so important to understand it properly, that I am sure you will try to do so.

It is another example of a hollow involuntary muscle, and just as you filled an indiarubber ball with water to represent the heart and squeezed it out to represent its contraction, so you could fill the indiarubber ball with paste and knead it about in your hand to represent the contraction of the stomach. In the picture you see the lines go in three different directions. This means that the muscle fibres run in three different directions; if you want to mix the paste inside the ball you squeeze it now in one direction and now in another by altering the shape of your hand, and this is just what the stomach can do by its muscular coats.

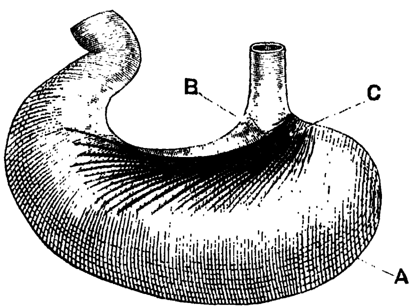


FIG. 45.—THE THREE MUSCULAR COATS OF THE STOMACH.

In this way the outer coat (*muscular*) of the stomach mixes up the food that has been swallowed, moving it

somewhere else directly any of it settles or touches the inside wall of the stomach, which, you must not forget, resembles the gullet, in not only being soft and wet, but in being well lined with the inner or gland coat (*mucous*).

In the meantime what is the inner coat (*mucous*) doing? It is not idle, for it is secreting and pouring out large quantities of a juice called

The Digesting Juice (*Gastric*).

In Chapter XXV. you were told about two sorts of glands, and how one sort—the preparing gland (*secreting*)—had the power of taking from the blood certain materials, making out of them a certain fluid, and storing it till it was wanted.

The inner coat (*mucous*) of the stomach is very full of a special sort of these little glands, which are called

The Digesting Glands (*Gastric or Peptic*).

You have all seen them in tripe. Fig. 46 is a picture of one of them.

The narrow white pocket at the bottom of the figure is the gland, and we must imagine the food tumbling about where the word "food" is marked. Directly it touches the little mouth or duct, the white pocket, which is full of the digestive juice (*gastric*), pours it out, and each particle of food gets some as it is moved to and fro by the muscular coat.

"Oh, master. I bad. I got pain. Trouble here," said a black man, laying his hand over his stomach. He was one of the sailors who worked the big house-boat in which we sailed up the Nile.

"Poor fellow," said my husband, and tried to make him describe his pain; but he knew very little English, and could not explain. So the dragoman, who was also the interpreter, had to be called in.

"Saar," he said, "yesterday was your religion day"—Christmas Day, he meant. "You gave all men one sheep. They like it—too much like it, and eat it all. Every day they not eat meat, only lentils. So to-day meat makes for him pain."

It was not very good English, but it was very good sense; and if you have learnt this lesson well, you will know why "meat made pain" for the poor vegetarian Arab. Those glands which usually work to produce the juices necessary to dissolve meat had in his inside become feeble from want of use. So, when he put into his stomach a great deal of meat, they could not secrete enough juice to melt it, and so it lay there hard and undigested, and the pain he suffered was what is called indigestion. If people eat quite different food from what they are accustomed to, they should eat very little of it.

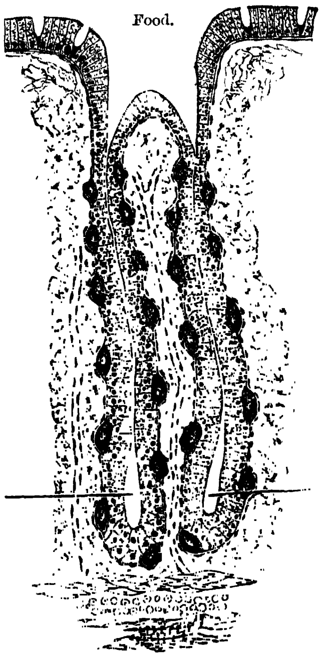


FIG. 46.—THE GASTRIC GLAND (*Peptic*), highly magnified.

A great deal of this digesting fluid (*gastric*) is secreted—so much that I am sure it will surprise you to hear the quantity; for never less than ten pints, and sometimes as much as twenty pints, are poured into the stomach every day.

If we could see it as it leaves the hundreds of little bags, bottles, or glands, it would look much like clear water, and a large proportion of it consists only of water. But it also has something in it which influences certain

sorts of food that have been eaten. The details of these changes is too difficult a subject for you. When the stomach has done its work the food is changed into a substance called

Food-Paste (*Chyme*).

The food-paste (*chyme*), once made, is immediately ready to leave the stomach, so it goes to the gate on the left-hand side of the picture, in order to get out. So far, then, have we taken the imaginary mouthful of food

From the gullet to the stomach door (cardiac orifice).
Through the stomach door (cardiac orifice) into the stomach.
There it was churned and mixed with gastric juice.
In the stomach it was re-named chyme, and
Brought to the gate of exit (pylorus).

In front of that gate we will now leave it, carrying it in the next chapter to still further foreign, or to it unknown, regions.

CHAPTER XXX

THE JOURNEY OF THE FOOD

FOOD-PASTE (CHYME)—THE GATEWAY (PYLORUS)—THE 12-INCH PIPE (DUODENUM).

In the last chapter we left the food-paste (*chyme*) waiting in the stomach ready to go through a little door, which is called

The Gate (*Pylorus*).

It does not swing on hinges or rise as if on rollers, like some of the other doors in the body. It is a different sort of door, and opens and shuts as a mouth does. When it is shut it is all pushed up together, like your mouth is when you are going to whistle. When it is open it is round, like your mouth is when you yawn.

Generally this gate (*pylorus*) is kept shut; but when the food-paste (*chyme*) is ready, or thinks itself ready, to go through, it pushes against the gate and asks to be allowed to pass on. The gate is kept shut by a round muscle called

A Tight Band (*Sphincter*).

It is the duty of the gate (*pylorus*) to let the food-paste (*chyme*) through, and it opens readily to do so; but if the food is not quite as fine a paste as it should be, the tight band (*sphincter*) draws together, and the gate (*pylorus*) contracts, or takes the shape of your mouth when a whistle is coming out, and the food-paste (*chyme*) is not allowed to go through.

Back then it must go into the stomach, and be churned again by the action of the muscular coats, until the paste has been made still finer and smoother, and fit to go through the little gate (*pylorus*) and past its sensitive walls.

"I have got such a pain. The doctor says it is indigestion, but no medicine seems to do it any good," a poor friend of mine said to me the other day.

"But what do you eat that does not agree with you?" I asked.

"Nothing different from usual," she said; "but, you see, I have hardly any teeth now, and so have to swallow the food without much biting. But," she added, "I don't think that ought to matter; doctor's stuff ought to get over such little troubles as no teeth."

No, I thought; no doctor's stuff will "get over" that tight band muscle (*sphincter*), or induce it to open and let food through which has not already been reduced to the proper consistency of food-paste (*chyme*).

You will see now why it is so important to keep the twenty-eight teeth in good order and use them properly, for the stomach cannot do the work they are made to do.

Here is a picture that will show you the gate (*pylorus*), and also a great deal more about the digestive organs. We shall often refer to it.

After passing through the little gate (*pylorus*) the food

paste (*chyme*) finds itself in a long, narrow tunnel, something like the gullet (*œsophagus*). This pipe or tunnel is called

The 12-inch Pipe (*Duodenum*).

You will see it in the picture on the left-hand side of the stomach.

In people who are quite grown up it is about 12 inches

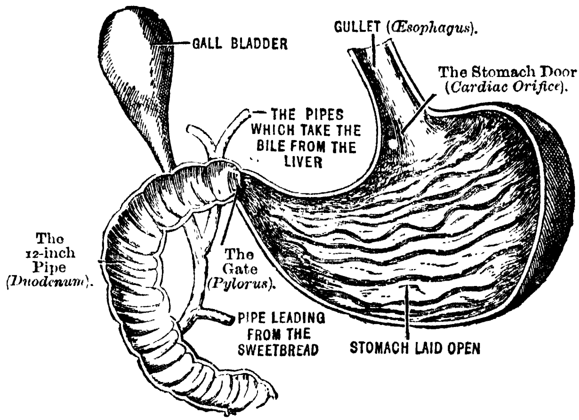


FIG. 47.—THE STOMACH AND DUODENUM.

long, and that is why it is given this name. Study the picture carefully, and you will see where two tubes enter into the 12-inch pipe (*duodenum*). These pipes come from—

The Sweetbread (*Pancreas*). **The Gall Bladder.**

But as you yet know nothing about the sweetbread (*pancreas*), or the gall bladder, or the liver, so we must leave the food-paste (*chyme*) resting in the 12-inch pipe (*duodenum*), while we try to learn a little about them.

"Resting," did I say? That was a wrong expression. Not for one moment will the food-paste be allowed to rest, for the 12-inch pipe (*duodenum*) is surrounded by

the same four coats as the stomach, and so they will go on working, and as they work they will moisten and tumble about the food in the same way as it has been tumbled in the stomach. However long it is left there, the muscular coat will move it; whether we wish—will—it or not the muscles go on working, for, as you know, these coats are made of involuntary muscle (*unstriated*).

CHAPTER XXXI

THE JOURNEY OF THE FOOD

THE SWEETBREAD (PANCREAS)

In the figure on next page you will see the sweetbread clearly drawn, resembling somewhat a radish in shape; and you will also see where the liver is placed in the human body.

You may have seen the sweetbread of the ox or the sheep when it is sold in the butchers' shops. It, as well as the sweetbread (*pancreas*) of a human body, is a sort of pale pink or coral colour; it is about seven inches long, and broader at one end than at the other.

The Work of the Sweetbread (*Pancreas*) is to secrete a fluid. It takes from the blood certain materials, turns them into something else, makes a fluid of them which it pours into the 12-inch pipe (*duodenum*); where the fluid joins the food-paste (*chyme*), and tumbles about with it and the bile until all is well mixed together. The fluid which the sweetbread (*pancreas*) secretes is called

The Pancreatic Juice.

The pancreatic juice does very much for the food-paste (*chyme*) what the spittle did for the food in the mouth.

When I was a child, I was often very naughty, but I had a good and devoted nurse, who did all she could to teach me what was right. One day I took my biggest doll out for a walk.

"You will get tired of carrying her," said nurse. "You had better leave her at home."

"No, I shan't," I replied; "I never get tired of having her;" and in my own mind I remember silently thinking, "If I do get tired, you will carry her."

"Well, do as you like," said the kind woman.

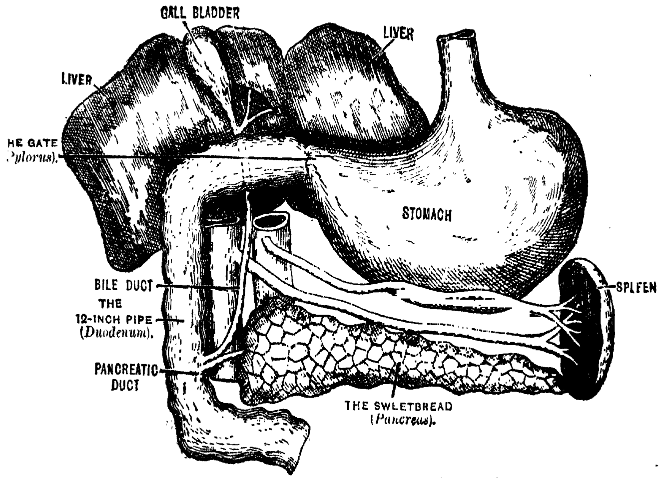


FIG. 48.—SHOWING THE POSITION OF THE LIVER, STOMACH, SWEETBREAD. SPLEEN, AND 12-INCH PIPE (*DUODENUM*).

During the walk my arms ached with carrying the heavy toy.

"Please, carry Minnie," I said to nurse.

"No," she replied; "I advised you not to bring her, and now you must carry her."

"I won't," I said in a rage; and I sat the doll in the hedge and left it. On we went, I very uncomfortable, and nurse very firm; but at last she gave way, went back, fetched the doll, and carried it herself. She was like the pancreatic juice, and picked up what another had neglected. It would have been much better for me to have carried the doll. It would be much better for the

teeth and spittle glands (*salivary*) to do their own work; but when they do not, the kind nurse, sweetbread (*pancreas*), works to make up their neglect.

It is better for every reason that the spittle (*salivary*) glands should be made or allowed to do their own work, which they will do if the food is chewed enough, and kept a sufficient time in the mouth; but if through carelessness or necessary haste the food is swallowed too quickly, the sweetbread (*pancreas*) will have to work extra hard to make up for the neglect of the mouth glands. It is a pity that this should ever be the case, for overwork of glands, as well as of people, is likely to produce illness.

You will now be able to understand another reason why the old lady of whom I told you in the last chapter got indigestion.

Because she had no teeth the food was not chewed enough, and so the stomach and its glands had to work harder. Its muscles had to work till they were weary and ached from fatigue: its glands had to secrete more juices, and pour out more and more liquid to melt the unchewed food, until they were limp and weak with weariness.

But this was not the only mischief done. Because she had no teeth the food was hurried out of the mouth before the spittle (*salivary*) glands had had time to change it, as they ought to have done, and so the sweetbread (*pancreas*) had to do the left-undone work. It had to secrete more pancreatic juice, and pour more than nature rightly bade it to do through the little tube which you will see quite clearly marked leading to the 12-inch pipe (*duodenum*) in the picture on page 111.

We began the last chapter with the food lying in the stomach, waiting to go on. We have taken it

Through the gate (pylorus). Into the 12-inch pipe (duodenum).
There it has been churned by muscular action.
Mixed in with pancreatic juice.

It is now thinner than it was in the stomach, but it

cannot even yet go on until it has been helped by more juices, so we must still leave it in the 12-inch pipe (*duodenum*) a little while longer.

CHAPTER XXXII

THE JOURNEY OF THE FOOD

THE INTESTINES

We left the food-paste (*chyme*) in the 12-inch pipe (*duodenum*).

With it the stomach had worked, on it the glands had poured their juices, over it the bile had been scattered, and all the time the muscles had never stopped moving, so that every part should be rolled together.

After being well mixed, the food-paste (*chyme*) is no longer the same thing. It has been a great deal altered, and is ready to move on. From the 12-inch pipe (*duodenum*) it passes into

The Intestines,

which are long pipes called

The Small Intestine. The Large Intestine.

Fig. 49 is a picture of both the intestines.

The small intestine is a sort of long tube or pipe about three-quarters of an inch thick, and perhaps twenty feet long. As you see, it is twisted and turned about, and made to content itself with a very small space. It is constantly moving and working; but before you learn about its work you must hear something about the coats of the intestine. It has four coats, like the stomach and the 12-inch pipe (*duodenum*).

I. **The Over-all Coat** (*Peritoneum*) contains the glands that make the serum fluid which enables the various parts

inside the body to glide over each other. As the small intestine is so long, so closely packed, and so constantly moving, it needs a great deal of serum to oil it and enable it to move easily and safely. So the over-all coat has many glands in it, and they work both hard and patiently.

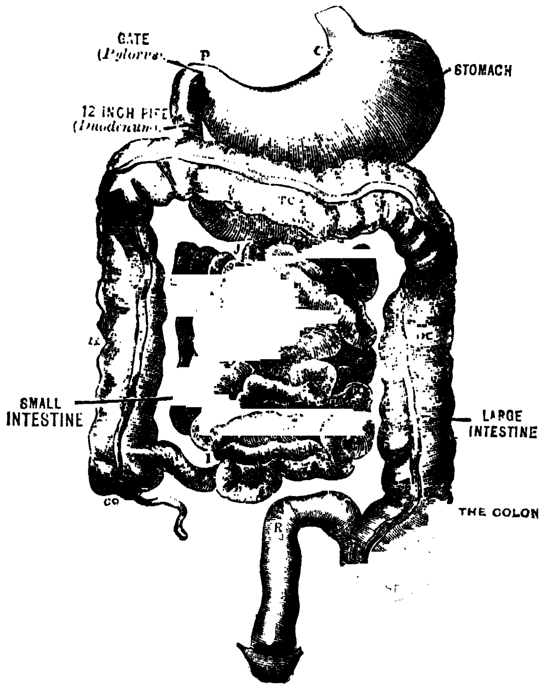


FIG. 49.—SHOWING THE STOMACH AND BOTH THE LARGE AND SMALL INTESTINES.

II. **The Outer Coat** (*Muscular*) has in the small intestine only two instead of three different sorts of muscles. It has only what we may call the "long-short" muscles and the "all-round" muscles, or those which in the picture of the stomach, on page 104, we called A and B.

Here is a picture which will show you more clearly the direction of the muscles in the small intestine.

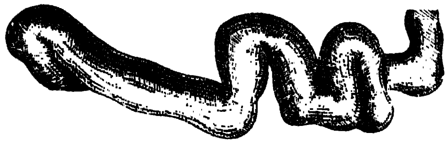


FIG. 50.—SHOWING THE TWO SORTS OF MUSCLES THAT COMPOSE THE OUTER COAT (MUSCULAR) OF THE INTESTINES.

In those lands where the sun has great power, it is of course much colder in the shade. One day in India we walked down a road where, if we had had a thermometer, it would have stood at 130 degrees. From there we turned into a courtyard closely shaded, with a fountain playing in the midst. Immediately the thermometer fell—20, 30, 40 degrees—settling finally at 88. It is these sudden changes that the little muscles around the intestines do not like. They are busy doing their work, stretching out lengthways, squeezing up roundways: suddenly they feel it cold, and the cold stiffens them so that they cannot go on moving so fast or so regularly as they ought. This being so, the food is not pushed along the small pipes; it stays in the intestines. Pain is the result, and sometimes serious illness.

When we were in Ceylon we heard of a young lady who lay a-dying of an illness brought on because she had neglected to wear extra flannel over her digestive organs.

"You had better do it," her friends said; "we all have to wear extra flannel here."

"Extra flannel! in summer weather," she exclaimed. "I can't do it. How could I teach in this melting heat weighed down by more clothes?" She was a teacher, and had come out to try and show the little black children some of the good and beautiful truths that are in the world.

"You need not fear," she said; "I am so strong, and I never catch cold."

But she did, and her brave work was stopped, and

the heathen children, for whose sake she had left home, country, and friends, remained untaught.

III. **The Middle Coat** (*Connective*) is the third coat which enwraps the intestines. Its duty is to join and yet divide the other two.

IV. **The Inner Coat** (*Mucous*) is the fourth coat, and about this there are various interesting things to tell you.

The inner coat (*mucous*) of the little intestine, like the inner coat (*mucous*) of the stomach and the duodenum, is full of glands which secrete fluid. The fluid they make is called the

Intestinal Juice,

and it seems to have the power of finishing up all the work that has not been quite completed in the mouth, the stomach, or the 12-inch pipe (*duodenum*).

As the food is moved up and down, it touches these glands which thickly line the small intestine. Immediately they pour out their fluid, and all that is in the food which is not yet fit to be absorbed by the blood is mixed with other juices. At the same time that this is happening, that part of the food which is already in a fit state to be taken and used is being absorbed by the villi or shaggy hairs of which I shall tell you in another chapter. The reason why the small intestine is so long is in order to provide a larger surface from which the useful part of the food may be absorbed.

"But how does it get into the blood?"

To explain *how* must be reserved for another chapter. We have followed the food as it journeyed, and seen it—

Taken out of the 12-inch pipe (duodenum).
Brought into the intestines.
Churned afresh in the 20-feet tube.
Mixed with the intestinal juice.

And in the small intestine we must leave it while you learn of yet another organ. It is called **The Liver.**

CHAPTER XXXIII

THE JOURNEY OF THE FOOD

THE LIVER, ITS WORK AND ITS STORE-ROOM—THE GALL-BLADDER

The Liver is a large organ divided into two parts, the part which lies on the right side of the body being larger than that which lies on the left-hand side. Each part is called

A Lobe.

The liver of a grown-up person weighs from fifty to sixty ounces. If we could see it, it would seem to be of a brownish red colour. The outside of it is flat and smooth, the under part rough and uneven, and broken by the pipes going in and out of it.

Many are the wonderful organs which are encased within the skin, but there is hardly one more wonderful or more interesting than the liver.

As you know, a gland is an organ which has the power of secreting or separating from the blood certain materials which it needs.

The liver is a gland which secretes like other glands, and yet it has many differences. First, it is much larger than any of the others; indeed, if all the spittle glands (*salivary*) were put together they would not weigh a sixteenth part as much as does the one big liver gland. Then all the other glands are surrounded with blood-vessels, and so is the liver, but within it all the vessels are squeezed so close together that cells, ducts, and blood-vessels all appear as one dense mass. You know, when you eat liver, you notice how "close the meat is."

Most glands, like the spittle glands (*salivary*) in the mouth, or the gastric glands in the stomach, take only what they want out of the blood, but the liver does something else besides this. It not only takes from one sort

of blood what it—the liver—wants, but it removes from another sort of blood what it—the blood—does not want.

It is like a ship which, trading with Australia, stops at Melbourne to take in food and water for its own use, but at the same time it brings away a cargo of rabbits, which are there in such large numbers that they destroy the crops and consume the vegetation.

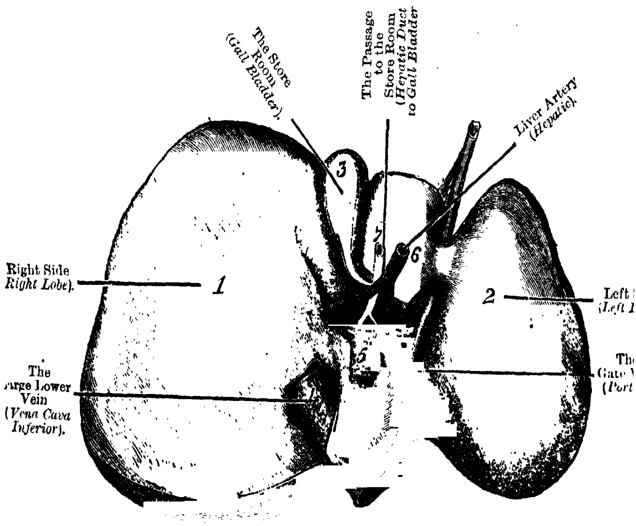


FIG. 51.—THE UNDER SURFACE OF THE LIVER.

1, right lobe; 2, left lobe; 3, gall-bladder; 4, vena cava inferior; 5, portal vein; 6, hepatic artery; 7, hepatic duct.

In order the better to understand this wonderful organ, you must imagine the liver to be a palace containing not ten or twenty, but hundreds of rooms—and yet the word palace hardly describes it, for all the rooms are work-shops. In each one very important work is done. There are two entrances by which things get into this palace, and two for them to leave.

About each of these doors, and what goes through them, we will now speak. The first is called

The Gate Vein (*Portal Vein*).

You will not have forgotten that around the stomach and sweetbread (*pancreas*) there are hundreds of little blood-vessels, and that these take from the food as much material as they can carry. When they have taken everything they can get they carry it all towards the liver, and it is the gate vein (*portal vein*) which conveys it into that organ. Once inside it is conveyed into one of the workrooms, which is called

A Lobule.

This workshop is not very big, only about $\frac{1}{20}$th of an inch in width, but within it wonderful changes take place. The rich blood is robbed of its richness. All that it does not want is taken from it, and made up into something else. This something else is called

The Bile.

The blood is then sent on again, but the bile is sent out of the liver by one of the doors, and conveyed round a corner into another tube which leads to the store-room, which is known as

The Gall-Bladder.

It is the shape of a pear. Fig. 52 is a picture of it.

"One of the doors," I said, and added nothing more about it; and yet you would like to know that it has a name, and is, in fact, a very important passage. It is plainly marked in the figure, and is called

The Liver Passage (*Hepatic Duct*).

It allows nothing else but the bile to travel along it, and nothing ever returns by it. Its only use is to convey the bile, which has been made in one of the workshops, out of the over-rich blood, into the store-room—the gall-bladder. Then whenever it is wanted

the bile is squeezed out of the gall-bladder by its muscular coat, and travels back the way it came as far as the corner and then through another tube to the duodenum (*v.* Fig. 48).

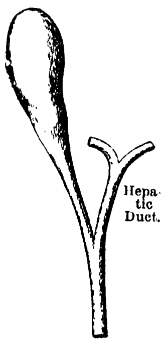


FIG. 52.—THE GALL BLADDER AND ITS DUCTS.

The liver is a wonderful organ, and it is both very useful and very industrious. Indeed, it never stops its work, for it has no "eight hours' day," and neither does it cry out for playtime. It works on all day patiently, only doing a little more extra work as soon as the stomach receives fresh food, and slackening off a little when its owner is very hungry. But it never stops still. It cannot work so hard without being well fed, and the food it requires is blood. Not dirty blood, but fresh blood lately cleaned and enlivened by the oxygen in the air. So the heart pumps towards it some of this bright red blood, which enters by the second of the doorways, which is called

The Liver Artery (*Hepatic*).

We have now seen that two sorts of blood enter the liver, each by its own door. The over-rich blood on which the lobule has had to work, and the fresh blood, which has had for its duty that of feeding this hard-working organ.

After all the work is done, both sorts of blood want to leave the liver. But there is only one passage by which they can leave. So as both have to use it, they wisely unite. You are too young too understand all the wonderful mechanism by which they unite, but after they have done so they leave by the vein, which is then quite tiny, but which, after it has joined others, and become bigger, is called

The Liver Vein (*Hepatic*).

You will see it in Fig. 53, exactly in the middle of the workshop (*lobule*), and marked with the figure 1.

Does the liver vein (*hepatic*) keep the blood?

No: it passes the blood onward until it reaches the largest vein in the body (*inferior vena cava*), which finally pours it into the heart.

And now we must return to the storehouse, where we shall find all that this industrious organ has made. It is called, as I have already said, the gall-bladder, and it contains the bile, and a great deal of it too, for every day

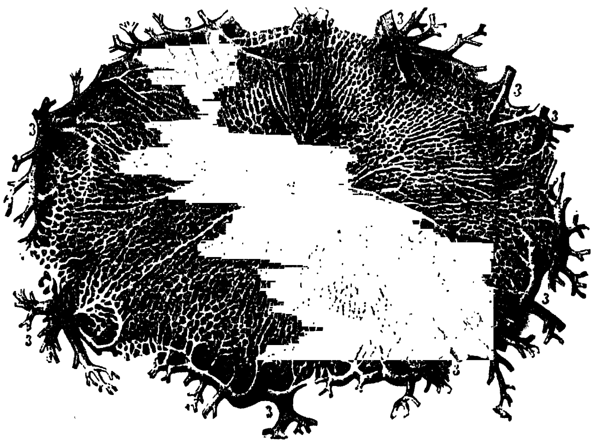


FIG. 53.—CROSS SECTION OF A LOBULE. MAGNIFIED ABOUT 60 DIAMETERS.

1, intralobular vein; 2, its smaller branches, collecting blood from the capillary network; 3, lobular branches of the portal vein, with their subdivisions passing inwards.

no less than a pint and three-quarters is made or secreted by it. Secrete is the right word to use when speaking about glands.

The gall-bladder is very sensitive, and as soon as the food-paste (*chyme*) enters the 12-inch pipe (*duodenum*) it gets news of it, opens itself, and outpours the bile which the liver has secreted, and which it—the gall-bladder—has taken charge of until it is wanted. Down the little tube the bile travels, and enters the 12-inch pipe

(*duodenum*) towards its lower end. There it meets the food-paste (*chyme*), which is, as you know, being churned from side to side. It joins it, and is soon mixed in so well that it would be difficult to know the two apart.

"Mother says I am bilious, but I don't know what that means. Do you know?" asked a boy of his teacher.

"Yes, my lad, I know," said his master, "but it is too difficult for you to understand."

Is it too difficult for you, my pupils, or do you think you understand a little about what being bilious is? Anyhow you now know that it has to do with the liver, which makes the bile that is stored up in the gall-bladder. Sometimes biliousness is caused by the liver working too hard and secreting too much bile, and sometimes from other causes. The liver is easily influenced by beer or spirit drinking, and there are few diseases more horrible than what is known as the drunkard's liver.

I have only told you of a part of what the liver does. There are a great many other things that it does besides, but I do not know myself how it does them, so we must all wait until the wise men have found out about it and let us know.

CHAPTER XXXIV

THE JOURNEY OF THE FOOD

HOW FOOD GETS INTO THE BLOOD—THE ABSORBENT SYSTEM

In a previous chapter we left off with a question, which we must now try to answer and to understand.

"How does the food get into the blood?" I do not think that I told you that the inner coat (*mucous*) of the little intestine is all in folds. The object of this is to allow more room for the glands which, either of one sort or another, are closely packed all over the lining of the

intestine. Here is a picture which will show you partly what is meant.

In this picture some part of the outer coat is taken away, so we are looking, as it were, inside the small intestine. You will see the folds. It is as if we had pleated a yard of fine silk into a fur muff.

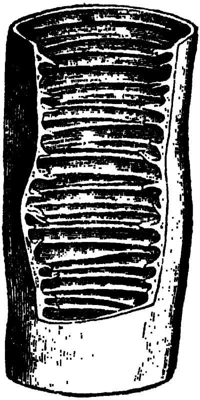


FIG. 54.—PART OF THE SMALL INTESTINE LAID OPEN SO AS TO SHOW THE FOLDS.

But besides the glands which make or secrete the intestinal juice, there is something else packed away amid these close folds, and there are tiny mounds no bigger than hairs. A great many of them there are, so many indeed that you will be astonished to hear the figure, even if you cannot realise the number. Four million little greedy hairs are mixed up with the secreting glands, all lying close together, ready to do their work. Fig. 55 is a drawing of them.

"What is their work? and why do you call them greedy?" I fancy I can hear asked.

Their names, though, I must first tell you. They are called

The Shaggy Hairs (*Villi*).

The duty of these shaggy hairs (*villi*) is to take up the food from the intestine and use it.

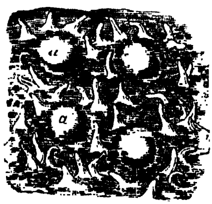


FIG. 58.—A BIT OF THE INNER COAT (*MUCOUS*) OF THE SMALL INTESTINE.

Fig. 56 is a picture of two very much magnified.

In the centre of each of the shaggy hairs (*villi*) is a small white tube. This is called

A Milk Tube (*Lacteal*).

Sometimes a shaggy hair (*villus*) has one milk-tube

(*lacteal*), as you will see is the case with the left-hand *villus* in the picture. Sometimes it has two milk-tubes (*lacteals*), and you must notice that the right-hand shaggy hair (*villus*) is drawn with two of these tubes.

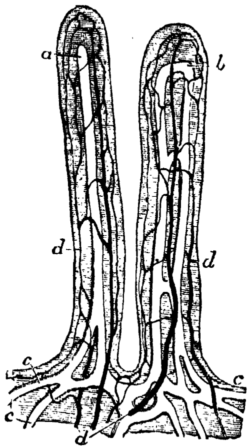


FIG. 56.—TWO SHAGGY HAIRS. MAGNIFIED 100 DIAMETERS.
a, *b*, and *c*. Lacteals. *d*. Blood-vessels.

But besides these white tubes you will see black lines which represent tiny blood-vessels. As the food tumbles about in the intestine, it is continually getting through the thin skin of the shaggy hairs and passing either into the tiny blood-vessels or into the white tubes. That part which goes into the blood-vessels is taken to the liver by them, as you will learn in another lesson.

That part which passes into the white tubes is the fatty part of the food, such as milk, and that is why the tubes are called milk tubes. The name given to their contents is

Chyle.

If now I were to ask you: How does the food get into the blood? do you think you could answer me? First of all try, and then I will answer for you.

There are two ways; one the short direct way, the other, the long roundabout way. Most of it goes the short direct way into the tiny blood-vessels which are everywhere just underneath the mucous coat of the stomach and intestine, and which you saw in the picture of the villi, Fig. 56. But a part of the food—namely the fatty part—goes a roundabout way, first into a small milk-tube, then into a larger milk-tube, and finally into a lymphatic vessel where it is joined by *lymph* from other

parts of the body with which it mixes. At length it enters the largest lymphatic vessel in the body, called the

Thoracic Duct.

This conducts it to a big vein at the base of the left side of the neck, and so this long journey comes to an end, and the fatty part of the food at last enters the blood.

CHAPTER XXXV

LYMPH AND THE LYMPHATIC VESSELS

At the end of the last chapter I used the words *lymph* and *lymphatic vessel*, and some of you were set wondering what I meant by them. I am going to try and explain now.

The *lymph* is a fluid that comes from all the different parts of the body, and most of it comes from those parts which are in most active use—the muscles. To understand this you must remember that the muscles need to be constantly fed in order that they may be able to do their work. The food of the muscles is contained in the blood, and there are countless little blood-vessels in every muscle. But the blood is no good to the muscles so long as it stays in the blood-vessels. Suppose a fibre of a muscle is tired and is crying out for more food. So long as the blood remains inside the vessel the fibre cannot get at it. So the liquid part of the blood is allowed to ooze through the walls of the vessel, and now the muscle fibre is bathed in the liquid which contains its food. The food is taken up and something else is given back to the liquid which the muscle does not want. But now the liquid, which is called *lymph*, is no longer any good to the muscle, and so the little lymphatic vessels collect it and carry it away to the larger lymphatic vessels, where it joins the chyle from the villi, as I told you before.

A Lymphatic Vessel

is a sort of very fine tube, but it is not like other tubes, for it has inside it a wonderful little contrivance, which is, however, best explained by a picture.

You must know that the figure marked A is the picture of one of these vessels when laid flat open, but that when it is closed it will be round like a little tube, as we see in the figure marked B.

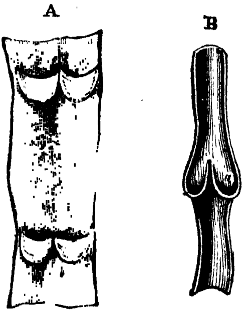


FIG. 57.—DIAGRAM SHOWING VALVES.

A, part of a lymphatic vessel laid open, with two pairs of valves; B, longitudinal section, showing the valves closed.

Now, in each lymphatic vessel there are many little flat bags lying up against the side of the tube. When they are empty they are flat, like the drawing on the right of Fig. 58. The lymph goes rapidly past them; they "lie low," and one might be in danger of even forgetting they are there. But if any of the lymph by mistake wishes to flow the wrong way, or return to the little white milk-threads (*lacteals*), then these little bags quickly fill: they bulge out and take the form that is shown on the left of Fig. 58, and make barriers past which nothing can go.

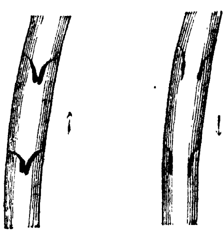


FIG. 58.—SHOWING THE VALVES WHEN OPEN AND SHUT.

Very close together are these little valves, so close that when the lymph vessel is full it looks like a fine cord in which some one has tied many knots. If the valves are empty and lying close against the walls of the vessel, they take up only a little bit of room, but when they are full the knots stand out more.

What makes the lymph go forward in these tubes? You will learn in another lesson that the blood moves for-

ward because it is made to do so by the big muscle that we call the heart. In some animals—for instance in frogs —there are separate little hearts for sending the lymph forward in their separate little vessels, but in man there is nothing of the kind. What, then, makes the lymph go forward? Before I can answer that question, I must ask you to remember where the lymph comes from. It comes from all the different parts of the body, and most of it comes from the little spaces round the muscle fibres. Now you can easily understand that when a muscle contracts it makes these spaces smaller and so squeezes the lymph on into the vessels, and once in the vessels you know it cannot go back because of the valves, and must therefore go forwards.

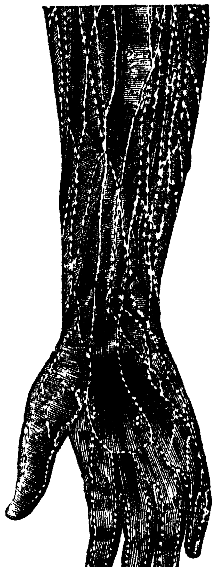


FIG. 59.—THE LYMPHATIC VESSELS OF THE HAND AND ARM.

Here is a picture which will show you the lymphatic vessels which lie on the outside of the arm and hand, and there are similar networks in, amid, and around all the organs, and on every part of the body.

Before we leave the subject of the lymph, I must tell you what is meant by a

Lymphatic Gland.

In Chapter XXV. you have learnt about two sorts of glands already, the Preparing and the Separating glands. A lymphatic gland has nothing whatever to do with either of them, so that it is a pity that it is called by the same name. What then does it do? Look at the picture and you will see that it is a struc-

ture to which some vessels bring lymph and from which others take lymph away. I don't know why some vessels are made so much bigger than others in the picture, but I suppose that in the big ones the lymph is trying to go the wrong way, and the little bags are trying to prevent it from doing so. However that may be, in the course of all lymphatic vessels, these "glands" occur at more or less frequent intervals, and one of their uses is to act as a filter. You would understand this if you could see some of these glands near the lungs in a person who had lived all his life in London. It would be quite black from the smoke which he has been breathing into his lungs with the black fogs. But if you could see a gland in the same part of the body in a villager from the country, it would not be black at all. Perhaps if our governors could see these glands they would devise better means to do away with the smoke.

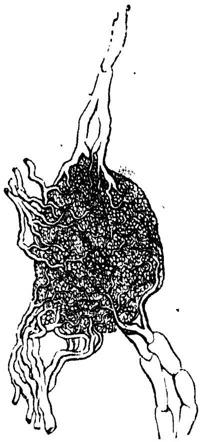


FIG. 60.—A LYMPHATIC GLAND MUCH MAGNIFIED.

CHAPTER XXXVI

THE JOURNEY OF THE FOOD

THE FOOD'S LAST STAGE — THE COLON

THE food has very nearly finished its journey. After this lesson we will part from it, but before we do so you must learn about yet another organ. It is called

The Milt (*Spleen*).

In the picture below you will see it plainly marked. It is about as big as your closed-up fist, weighs about as much as the fourth of an ordinary loaf (*half a pound*), is spongy in its texture, is dark-reddish purple in colour, and in shape it resembles both a mushroom and one of the quarters of an orange.

Can you picture this queer thing? It is always a good

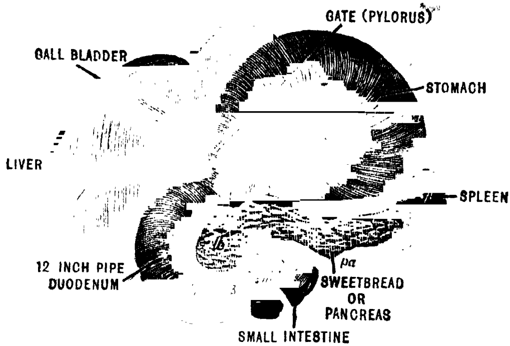


FIG. 61.—SHOWING THE POSITION OF THE DIGESTIVE ORGANS WHEN FOLDED WITHIN THE BODY.

plan, when a thing is described, to try and picture it all clearly in your mind. Say to yourself, This organ is

As big as ——— As heavy as ———
In texture like ——— In shape like ———
Its colour is a ———

And now that you have each pictured it, so now we will ask—What is its work or use? and I shall have to answer—No one knows yet. There are learned men in all parts of the world who are studying, looking through the microscope, and doing all that is possible so as to find out. A great deal is already known, but as yet no one feels quite sure of the exact use of this milt (*spleen*). It is generally believed to influence the blood, and those two pipes which you see are drawn in the figure as coming from it are blood-vessels.

But now I want you to understand that the organs do not each stand out straight as they are shown in Fig. 49. They are only so drawn to make it easier for you. This picture will show you more how the organs look when they are folded up and packed away in the body.

We followed the food as it journeyed from the mouth to the small intestine, and there we left it while you learnt something of the wonderful arrangements by which it became absorbed into the blood. We will now take it up where we left it and follow its journeys.

Constantly is the small intestine moving, moving with a worm-like movement, and the food within it slowly goes on; drawn by the long muscles, squeezed by the short ones, it never stops, till it has passed all through the small intestine and reached the large intestine. You must turn to the picture on page 114, and there you will see quite clearly where the little intestine runs into the big intestine. It is marked C, and is on the left-hand side of the picture. If you look carefully you will see that the big intestine, for a few inches, goes in an upward direction, then turns, goes across the body, and down again.

As you know, there is a wonderful law called the "law of gravitation," in obedience to which everything falls downward. Because of this law you would, perhaps, expect that the food would naturally fall back again into the smaller intestine; but in order to prevent it doing this there is a curious and wonderful arrangement in the large intestine called

A Valve (*the ileo-cœcal valve*).

When the food has once passed through the valve it reaches the large intestine, and the work of digestion begins again. The large intestine is called

The Colon.

It is about six feet long and about two inches thick. There are no shaggy hairs (*villi*) in the colon, but there are many blood-vessels, and these little greedy suckers

take up all the nourishment that has been left in the food, until at last nothing remains in the colon but waste.

If the waste material were allowed to remain in the body it would cause illness, so it is necessary that it should be ejected. For this purpose there are placed in the colon some delicate nerves which become irritated when they are touched. As the waste material touches and irritates them they set in motion some involuntary muscles, which slowly push out all that which the body no longer wants.

Now, my pupils, that you have learnt a few facts about the food, and how it becomes chyme and chyle and gets absorbed into the blood, you will the more easily understand why one sort of food is wholesome and another unhealthy.

All the children who belong to a Band of Hope have learnt that beer and wine and spirits are bad for health, and they are told that the spirit, or alcohol, which is in one and all of such drinks, inflames the blood and injures the body.

You also know a little of the reason why, for you have learnt something of the mucous membrane of the stomach. You have learnt how delicate and how numerous the gastric glands are, and it is not difficult to fancy how the burning spirit inflames them, and to believe that the alcohol, whether it be in beer, wine, or spirits, stimulates and yet fatigues these and other of the internal structures.

The liver is especially influenced by alcohol. Among its delicate tissues the spirit plays havoc, and many of the sad diseases of this organ are brought about by people drinking liquids containing alcohol.

Sometimes it is taken to help digestion, by which is meant the process of melting or changing solid food into a liquid. But if we go to a museum we shall see lots of little bottles full of liquid, in which are dead but solid animals.

"What makes them remain solid? why do they not melt into the liquid?" you ask.

The answer is that the liquid is spirit, and it prevents them from dissolving, and this is the same sort of spirit, or alcohol, which people put in their insides, with the mistaken idea that it will help the solid food to dissolve.

"How mischievous," writes one doctor, "is the drinking of alcoholic drinks, particularly during meals! How absurd the popular, but too often medical delusion, that they assist or promote digestion!"

And two wise professors, who wrote a big book, declare that, were it not that these drinks quickly left the stomach, it would be impossible for the stomach to do its work of digestion.

But besides alcohol there are other foods which are unwholesome. Sometimes one hears people who are not very rich say they are "too poor to afford much meat." If they knew more about physiology, they would not feel so sorry about this; but this is a large subject, and must be reserved for the next chapter.

CHAPTER XXXVII

FOOD AND DRINK

THE DANGER OF ALCOHOL

THE human body must eat three sorts of food. They are called

Body-warming Food (*Carbonaceous*).
Flesh-forming Food (*Nitrogenous*).
Mineral Food.

In meat there is a great deal of flesh-forming (*nitrogenous*) substance. In order to use it certain muscles and glands have to work very hard, and the kidneys and other organs have to get rid of the waste. If people eat more than a moderate supply of meat, they give some of these organs too much work to do.

We have, as friends, one family whose custom it is to eat largely of meat. They live in a beautiful park in the North of England. The father gives all his time and thought to serving other people and to making the lives of the poor and sad happier and richer. The pretty lady cares only for her children and doing kindly acts to those whom she knows. The children are all well-grown and active, and yet I never go to stay with them without feeling uncomfortable about them, for I cannot help knowing that their large consumption of nitrogenous food in meat will, sooner or later, make them ill. I see, in fancy, the father crippled with rheumatism, and the children suffering from wearied livers and the ills that follow the overstrain of the kidneys.

Once, when we were in Egypt, we stood on the quay at Suez watching the unlading of the luggage and bales from a large ship that had just come in. The English sailors, fed on beef, and getting their regular allowance of "grog," used the cranes and joined together to pull the ropes. On the quay stood the tall, stately, but thin Arabs. When it came to their turn to move the bales they just picked them up and walked off with them on their heads.

"Surely such loads would stagger any English porter," remarked my fellow-traveller.

"What do they eat?" was asked.

I learnt afterwards that their diet was chiefly bread made of wheat, millet, or maize, to which they added gourds, onions, beans, lupins, dates, and lentils; while the water of the pure, blue-brown Nile was their only drink.

In these foods there are to be found all that is necessary to warm and repair the body and to purify the blood.

Poor people need not therefore regret that they cannot get much meat. This, however, is a large subject, and one that I cannot now speak of, as I have already dealt with it in another little book called "The Making of the Home." Enough, though, has been said to show you that the alimentary canal should not be asked to digest any and everything, or it will suffer and be ill.

We may laugh at the story of the Indian gentleman who was overheard addressing his digestion.

"So you do not like pickles," he said, looking at the seat of his digestive organs.

"Well, you shall have them every day till you learn to like them;" but the laugh will not be unmixed with sadness, because the man was ignorant of, and therefore ready to injure the delicate machinery with which he had been endowed.

I must also tell you how important it is not to eat too much.

The amount we eat is largely a matter of habit. The stomach and digestive organs can only do a certain amount of work, so if a person eats more food than the stomach can properly work on two results follow.

The digestive organs try to do their duty on all that is given them, get overtired, and fail, therefore more has to go off in waste.

If less food is given, the stomach and digestive organs are able to take all the good that there is in it and use it every bit.

The Americans, the English, and the Germans eat more food than any other people.

The Hindoos eat very little, and the Japanese hardly exceed them. If we could see the conditions of these various peoples' digestive organs after their meals, we should see, in the case of the large eaters, good food that yet contains nutrition being sent on and rejected, because the digestive organs are too weary to abstract more good from it; and in the case of the small eaters, we should see every atom of nourishment abstracted from the food, the waste rejected being pure waste in which there is no food substance left.

People often eat too much because they think "it will do them good," and encourage children's appetites by the offer of tempting food. This is an error; and one of the many reasons why children should only be allowed to eat the simplest fare is because the digestive organs will themselves then limit the appetite to the amount that they can use without fatigue or wastefulness.

But besides food the body needs drink, in order to enable it to keep well and repair itself.

In all human bodies there is a great deal of water. If a man weighs 154 lbs., 111 lbs. of that weight will be water; or if we put it in another way, out of every 1 lb. and 6 oz. that there is in a human body, 1 lb., or 16 oz., is water

People sometimes think it is unhealthy to allow children to drink much water. They say it makes the blood thin. Few children take more water than they require; and, however much is taken, it will not weaken or dilute the blood, for the blood will only contain a certain amount of water.

The quantity which is drunk is also very largely a matter of habit. Some people are always wanting "something to drink," and these like to take liquid in some form, not only at meals, but at all hours. This is not a good habit, and one that should not be encouraged; for at first children only ask for water, but in later life they want beer, and too easily turn into the public-houses for a drink, to the ruin of their own health and the destruction of the happiness of those who love them or depend upon them.

A full-grown man who does active work, or takes a good walk every day, should not drink less than 3 or 3½ pints every day of water or tea, coffee or cocoa. Women, as a rule, do not do such active work as men, and so they do not need so much liquid; but in most cases people drink too little rather than too much.

I have told you about water, as if water were the only liquid that it was possible to drink; but as you know, this is not the case. In England we have cocoa, coffee, tea, beer, and wine to drink; and some people like taking spirits. It is commonly supposed that beer gives strength; and there can be but little doubt that a great many of the people who ruin their health and sadden their homes by taking too much strong drink began the sad habit by drinking beer, as they say, to "make them strong," or by taking spirits "to keep the cold out."

Neither does either. Beer does not give strength. Spirits do not "keep the cold out."

Nowhere is it so cold as in the Arctic regions. A while back a brave set of men offered to go and try to find Sir John Franklin, who was, alas! lost amid those vast lonely ice-fields. The ship was built and packed, and a plentiful supply of whisky, gin, and brandy was put in for the men's use; and all safely reached the land of ice and snow, and soon began their search. A "nightcap," as they called it, was served out to each one as he was huddled up in the skin bag that served for his bed and blankets, and then the last man out took an extra strong dose himself, and joined the others; and they were only too glad when morning came if they found no one's ear ready to drop off or his nose dead, because circulation had stopped and the frost had bitten it.

If ever it was cold, it was there; if ever grog could "keep the cold out," then was its chance.

Once a little band of the sailors tried to get across a great ice-field to see if something they saw by the field-glass was either the lost ship or the huts of the men they had come to find. It was very rough, hard walking, and the grog-barrel had to be left behind. What grumbles there were at no "nightcaps!" What fears that they should be frozen without the grog to keep the cold out! But when morning came, one man after another confessed to his fellows that he had been warmer than usual that night.

The news spread; other men tried to do without the "nightcaps," with the result that at last nearly all refused it, finding it useless.

I could tell you other stories about beer, and how the soldiers marching in the sweltering heat of Afghanistan found no strength in beer, and left it all behind in the desert, but this chapter is already too long.

CHAPTER XXXVIII

THE JOURNEY OF THE AIR

THE WINDPIPE

You have been told a little about the digestive organs, and how a mouthful of food became blood; and now you will learn how the air gets into the body, and the work it does there.

The air is all around and about you. Human bodies need fresh air, and die if they do not get it. The air has to get into the body. How does it do so?

First it enters by the nose, and goes through its passage, which is made longer by being twisted and turned about.

In the nose the air is both filtered and warmed. It is filtered by the little hairs which are inside the nostril, and by some wool-like threads which stick out and catch hold of the dirt in the air, and do their best to keep it from going any further. Thus people who breathe through their mouths run a greater risk of getting dirty things into their lungs than those who breathe through their noses and make use of the filter which has been wisely placed there for this purpose.

Besides being filtered, the air is also warmed as it goes through the nose. All around its bony plate blood-vessels are placed; through them the warm blood travels, and by their aid the passage gets some of the warmth of the life blood, and so becomes nearer the same heat at which the lungs are constantly kept.

It is even more important to breathe through the nose in winter than it is in the summer, because the lungs, being delicate, are apt to take cold.

After the air has passed through the nose, it enters the big chamber of the throat (*pharynx*).

There are, as you know, five doorways to conduct things in or out of that chamber.

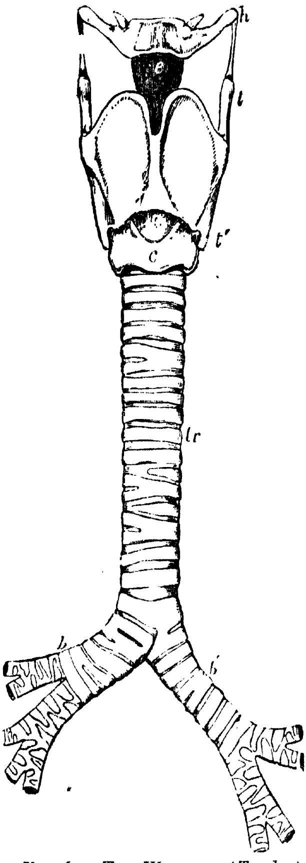


FIG. 62.—THE WINDPIPE (*Trachea*), *the Front.*

h, hyoid bone; *tt'*, thyroid cartilage; *c*, cricoid; *e*, epiglottis; *tr*, trachea; *b* and *b'*, bronchi.

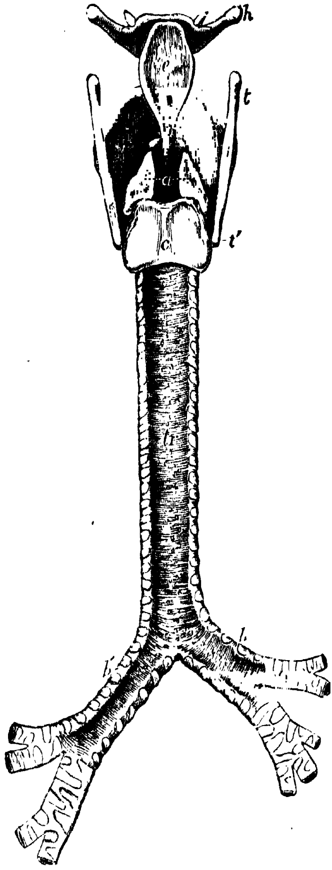


FIG. 63.—THE WINDPIPE (*Trachea*), *the Back.*

a, arytenoid cartilages; *h*, hyoid bone; *tt'*, thyroid cartilage; *c*, cricoid; *e*, epiglottis; *tr*, trachea; *b* and *b'*, bronchi.

1. **From the Ear** (*Eustachian Tube*).
2. **From the Nose** (*Nasal Passage*).
3. **Into the Lungs** (*Larynx*).
4. **From the Mouth.**
5. **To the Stomach** (*Gullet Œsophagus*).

The air has come in by the nose passage. Through which one is it to continue its travels?

If the air went into the stomach it would be wasted. Neither the ear nor the mouth wants it: it is needed by the lungs, and has to find its way into them. The road it has to take is by

The Windpipe (*Trachea*).

Opposite are two pictures of it. One will show you how it looks from behind, and one how it looks if the front of it is seen.

The Windpipe (*Trachea*) is a tube about $\frac{3}{4}$ of an inch wide and $4\frac{1}{2}$ inches long. It is made of strong round bands of cartilage. Hoops, I was going to write, but then I remembered that hoops went all round a thing, and that if I said hoops of cartilage you would think they went all round the tube or windpipe (*trachea*); but they do not. These bands go only across the front and a little way round each side of the windpipe (*trachea*), but they do not go across the back at all. Look at the picture and see what I mean. There is a very good reason for this plan. As you know, cartilage is hard and firm—indeed, sometimes it is very strong and unresisting. At the back of the windpipe, lying almost close by the side of it, is the gullet (*œsophagus*), down which the food travels.

Fig. 64 is a picture to explain to you the position of both the windpipe and the gullet.

When food is going down, the gullet is extended; it moves and becomes bigger if an unusually large mouthful is pushed onwards. Then the windpipe (*trachea*) politely gives way to it. It bends inward, as it were, and gracefully removes itself out of the way of the gullet (*œsophagus*). This it is able to do all the more easily because it

has no stiff, hard cartilage going quite round it. The portion that has to yield to the gullet is the back part, where there are no complete bands.

The top band of the windpipe (*trachea*) is called

The Shield Ring (*thyroid*).

It is wide in front, and sticking out in an angle, forms what is known as Adam's Apple. Behind it is like the others, soft and open; but the second ring is an all-round band.

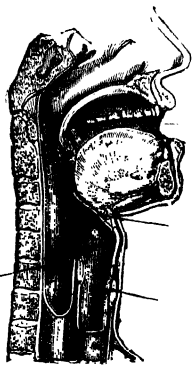


Fig. 64.—Showing the Positions of the Gullet (*Œsophagus*) and the Windpipe (*Trachea*).

Have you ever swallowed a very hard crust, or a bit of fish bone, or a bit of meat skin which stuck out and would not be rolled and chewed into a pill or soft ball? If you have, you will know that you felt a pain at the top of the throat, which went off as soon as the too hard or too big mouthful had gone down beyond that particular place.

Some people think that their gullet (*œsophagus*) is smaller at the top, near the throat, but that is not the case. The pain is caused by the hard mouthful passing

The Second Ring (*cricoid cartilage*)

of the windpipe (*trachea*); for as it is entirely round, there is no soft place, at the back, ready to squeeze itself out of the way when the gullet is wishful for more room. No; the second ring is a complete all-round one, and is hard and strong. So when the over-big mouthful passes, it has either to push the cartilage band, or else to extend

the gullet the other side. Both of which acts hurt, and that is why we have pain when we swallow anything which is too big or not enough chewed.

Perhaps it has been arranged that the second ring (*cricoid cartilage*) of the throat should go all round, and be hard and firm, to remind us that we must not give the stomach pieces too large for it, or bits of unchewed food that cannot easily pass down the gullet.

"John, do not bolt your food; you will suffer from it one day," was the advice given to a big lad of twelve one day by his mother.

"All right, mother," said the boy, "I'll wait till I do."

This was neither a courteous nor a wise answer; for Nature is an unforgiving friend, and, sooner or later, John would suffer from having "bolted his food," and having made the rest of his alimentary canal work harder, because teeth and spittle had not done their work.

CHAPTER XXXIX

THE JOURNEY OF THE AIR

THE WINDPIPE, ITS DOOR AND ITS LINING

In the last chapter we spoke of the journey of the air into the windpipe (*trachea*), and you learnt a little about its first and second rings and their power of adapting themselves to circumstances; but to-day I have something even more wonderful to tell you.

At the top of the windpipe (*trachea*) is a very beautiful and curious kind of contrivance. It is a sort of door which covers the windpipe, and it is called

The over door (*epiglottis*).

The slit leading into the windpipe is called

The Glottis,

and this little door is called the over glottis (or *epiglottis*).

Have you ever seen a little bird's tongue? The epiglottis is a tiny bit of active flesh like the tongue of a little bird. It is very sensitive, and directly it feels that any food has left the mouth and is coming past the glottis, on its way to the stomach, it drops down and covers the hole or slit called the glottis.

In a previous chapter choking was mentioned, and you were told how the nerve fibres told the news, and how the nerve cells gave the orders, and how the muscles acted to get rid of the crumb that had gone the wrong way. Now you will know that the reason the crumb went the wrong way was because the epiglottis had not been sharp enough. It had either not understood the news that food, or drink, or spittle was going to leave the mouth and enter the large chamber (*pharynx*), or else if it understood it had not done its work. It had stopped one moment too long before slipping down and covering the glottis, and so the travelling food had taken the wrong turning.

"We come of a choky family," said a sweet mother lady to me the other day, while a strong boy of fourteen thumped a delicate girl hardly, but not unkindly, on the back, because she choked. If the lady had talked in scientific language, she would have said—

"We come of a family where the epiglottis is not very sensitive," but we should have thought it both odd and pretentious of her. The greater people are, the less they pretend or lay claim to knowledge.

The over door (*epiglottis*) only shuts down when food is passing by, and generally it is open and admits the air quite naturally into the windpipe (*trachea*).

But we must return to the air, and follow it as it journeys, much in the same way as we accompanied the food as it travelled along.

It has to go down the windpipe (*trachea*) to the very bottom. If you have a cold, or if the air is very chilly, you will feel it as it passes right down the chest, exactly in the middle. At the end of the windpipe it divides into two tubes—one goes to the right-hand side of the

chest, the other branches off to the left-hand side. These two pipes are called

The Wind Tubes (*Bronchi*),

and their work is to convey the air on towards the lungs.

These two wind tubes (*bronchi*) are very strong and also very delicate. They in their turn divide and subdivide, and as they do so they get re-named and are called

The Bronchial Tubes.

They, as well as the windpipe (*trachea*), the bronchial tubes, and all the branches down to the tiniest, are lined with a wet skin (*mucous membrane*).

This wet skin (*mucous membrane*) is full of tiny hairs, which are called

Cilia.

They constantly move, gently swaying to and fro, and always pushing upwards towards the mouth. Their work is to catch any little bit of dirt or dust that may come in with the air, and push it out again, so as to prevent it getting into the finer bronchial tubes and air cells.

"My cough is so bad. I am nigh to choking oft-times," said an old Greenwich pensioner to me one day. He was a dear old man, and had been a brave sailor-soldier in his young days, being one of the people who had made England's "wooden walls" impregnable to her enemies.

"Oh no; you won't choke," I said to him; and then I had to explain all about the little cilia and their work of pushing upwards whatever was in the air tubes. I told him how the heavy phlegm would injure the bronchial tubes if allowed to stay there, and so the cilia pushed it up until it touched the top of the larynx, and could then be jerked up.

"Ah," he said, "I always thought man was clever; but there's somethings cleverer still."

From the bronchial tubes the air passes into the lungs.

About these wonderful organs you must learn in the next chapter. So far we have followed the air

Up the nose (*nasal passage*)	into the big chamber (*pharynx*)
Past the over door (*epiglottis*)	through the door (*glottis*)
By the voice box (*larynx*)	into the windpipe (*trachea*)
From the windpipe (*trachea*)	into the wind tubes (*bronchi*)
From the wind tubes (*brònchi*)	into the lungs.

It is absolutely necessary for the human body to have air, and fresh air, too.

The following story will prove this:—"There was once an emigrant ship that sailed from Liverpool. The men and women and children on board were going to leave Old England to work in a strange land. One night a dreadful storm arose. The ship tossed about so much that the captain ordered the sailors to send all the men and women and children down into a large room under the deck, because he was afraid they might be in the way. The sailors fastened the doors so that they could not get out. The storm went down in a few hours, when the captain told the sailors they might open the doors, or hatches, as they were called. The sailors took a candle, because the room where these poor creatures were put was quite dark. When they entered the candle went out. They lighted it again, and it went out a second time. This was done several times. At last it remained alight, and so they were able to descend. And what do you think they found? Nearly all the men, women, and little children lying on the ground—some of them dead, others unconscious. The only air they had had to breathe was the air that had come out of their mouths."[1] And as that was *not* fresh air, it had poisoned them.

This is a sad story, but it taught a great lesson, for no one now puts either people or animals into rooms where fresh air cannot get in; though few people, even among those who know something of physiology or anatomy, are quite as particular about methods of getting fresh, clean air into their houses as they should be.

[1] "Health in the House," by Mrs. Buckton.

It was because the air was dirty, or poisonous, that the people shut up in the ship died, for our bodies need all the oxygen that is in the air. Each time any of these poor people took in a breath, more of the wholesome oxygen was used up: each time any of them breathed out a breath, more of the poisonous carbonic acid gas was in the room; and the absence of the oxygen and the presence of the carbonic acid was what caused some to die, and others to become unconscious.

CHAPTER XL

THE JOURNEY OF THE AIR

THE LUNGS

If we could see the lungs themselves they would look a sort of darkish blue red. You may have seen the lungs of animals hanging up in the shops. They are then called **lights**. They look that colour because of the blood that is still left in them; but if we could strain out all the blood that is in them, and in other ways prepare them, they would look like two things, and two very different things.

First, they would look like a tree with trunk and branches and twigs, and

Secondly, they would look like a sponge.

Now I must tell you why, and on next page is a picture which will show you one lung looking like a tree, and the other resembling a sponge.

We will first talk about the tree-like appearance of

The Lungs.

After the windpipe (*trachea*) has divided into the two tubes (*bronchi*), they in their turn divide again into three other pipes, each smaller than the tube. They divide again, and each gets smaller as it divides and divides and divides, until the last and smallest tube is only

about the fortieth part of an inch big, and the windpipe is, as you know, in a grown-up person one inch

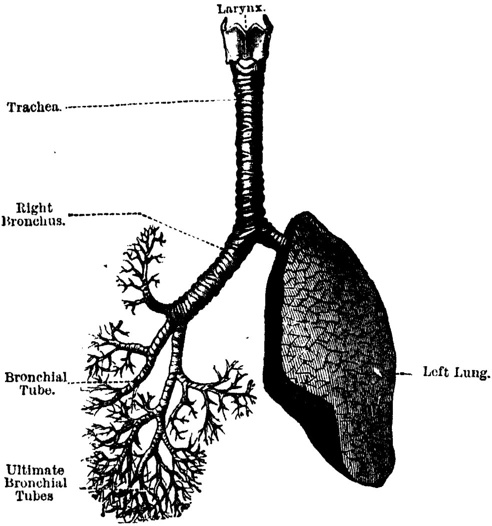


FIG. 65.—THE TWO LUNGS, ONE DISSECTED TO SHOW THE AIR TUBES.

broad. At the end of each of these tiny tubes is an air cell.

Fig. 66 is a picture of a group of air cells.

Every time we draw breath we take in the air, which, as you know, travels down the windpipe till it reaches the two bronchial tubes. It takes its choice which of these two it will use. If it goes into the right lung, it will find three divisions waiting for it to fill. If it goes into the left lung, it will find but two—lobes they are called; but whichever lung it chooses to use, its work will be the same.

Down one of the tubes it will go, dividing itself as the tubes divide, until at last the air will find itself at the end of the tiniest of all the tubes, and ready to fill all the little air cells which are waiting empty for it

They are close together, and look like the little holes in a sponge. Now you will know why I said that the lungs look both like a tree and a sponge. They branch out as a tree branches, but at the end of each of the tiniest of the twigs is this little arrangement of air cells which makes them look like a sponge.

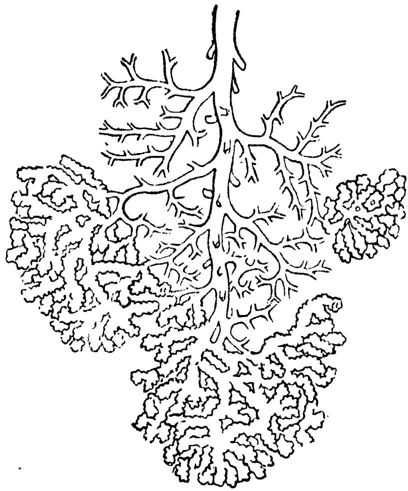


FIG. 66.—A GROUP OF AIR CELLS AT THE END OF A SMALL BRONCHIAL TUBE.

So far, then, we have followed the air. "Do we leave it in the air cells?" "Yes" and "No." "Yes" because some of it is left there, and "No" because some of it returns by the same way as it entered into the outside air, changed though, quite changed by the work it has done while it has been in the lung. It went in—

Oxygen	21 parts
Nitrogen	79 "
	100

It comes out—

Oxygen	16 parts
Nitrogen	79 "
Carbonic acid	5 "
	100

It has become dirty by making the blood clean.

All around these bronchial branches and twigs are

hundreds, nay, thousands, of little tiny blood-vessels. They have very thin walls; indeed, they are so thin that what is inside them can pass through them.

Are these not strange walls? They are thick enough to keep all they wish to keep inside them—they are thin enough to allow all they wish to go to pass through them.

From the blood-vessels to the air cells passes the substance called carbonic acid which the blood wants to get rid of. From the air cells to the blood passes the substance called oxygen, of which the blood has need, in order that it may carry it to the muscles and the brain, which without it would die. Now you will see why it is important always to breathe fresh air, for it is only **fresh air** that has the power to clean the blood and make it fit to do its work of feeding the organs and sustaining life.

In 1757, not very long after the English first went to live in India and trade with the Hindoos, the natives tried to get rid of the English. They made war against us, and gained several victories. The English fought bravely, for they were fighting not only for their homes and fortunes, but for their lives and liberty; but at last the enemy was too strong for them, and one of the native princes, called Surajah Dowlah, took 146 English men and women prisoners, and put them into a tiny room below ground where there was only one small window.

It was intensely hot, and the prisoners were weary and very thirsty. They all crowded to the window to get what air they could. This was not wise, as they thus kept the air from getting into the room; but which of us, who are often self-seeking in little things that do not much matter, can blame them who were struggling for their lives? But it was all of no use. Not enough air could get into the room through that tiny window to feed all their lungs, and in the morning it was found that no less than 123 were dead. They had died because there was not enough air to go into their lungs and fill their air cells and purify their blood, and so the dark blood had poisoned them and they had met death.

It is told that some of the positions of the dead bodies told tales of unselfishness and love even during that dreadful night. One lady was found who had evidently held her husband's head up towards the window until she herself had dropped from want of air.

This is a dreadful story, and it is not often that such sad results happen from want of fresh air. No; as a rule people do not die from want of air, but they become weak, and poorly, and low-spirited. If only everybody would open their windows more, and make it a rule to sleep with the window open but one little inch, even if it be only one, at the top, in the winter as well as in the summer, they would all become

Healthier, Wealthier, and Wiser.

But if fresh air is necessary for people when they are well, it is still more necessary for those that are sick.

A gentleman, who went out to serve as a doctor in the great war between the French and Germans in 1871, told me that when the hospitals were full, the wounded soldiers had to be put into the churches; and when they were full, barns and tents hastily rigged up had to be utilised, for the terrible mitrailleuse gun shed wholesale death or wounds around. The nurses and everybody felt sorry for those wounded men who had to go into the tents or draughty barns, but when the results of the nursing were counted up, it was found that the more air the invalids had had, the better they had got on. Fresh air had helped both the doctors and nurses.

Of the three things necessary to the body, *air* is the most important. People can live longer without food than they can without drink, and longer without drink than they can without air. Air, then, is the chief thing that the body wants, though it is true, as people often say, that "we cannot live on air," but require also food and drink.

Not all the air that goes into the lungs comes out again. Some of it remains in the air cells. This is called

Stationary Air (*Residual*).

In each person's lungs there should be 230 cubic inches of air, and this should be changed, gradually changed, by the fresh air that comes in. Each breath we take would occupy, if it could be measured, about 26 cubic inches, and we breathe about sixteen or eighteen times in a minute. So you see that it will take about half a minute to change all the residual air. You may ask, "What is the use of the stationary air?"

It has two uses. By staying longer in the air cells, it gives the little blood-vessels more time to get out of it the oxygen that they want, and also it is warm. If all the air that the blood wanted came in fresh every time, on a cold day it would be very cold, and would chill the blood; but, as it is, only the tenth part of what is wanted comes in cold, and that is soon mixed with the air which is already inside and is warm. Some of the new air and some of the old air both go out together, leaving some of both sorts inside to do the work of blood purifying.

But what makes the air move between the outside room and the lungs? "Oh, because we are always breathing it in and out," somebody says. Yes; but can anybody tell me what he means by *breathing?* *Breathing* is a muscular action. You have many of you used a pair of bellows to light a fire when it won't "draw" easily. You alternately draw air into the bellows and send it out again, and you know that if you go on for long it is hard work and the muscles of your arms get tired. The lungs are a sort of bellows by which we draw the air in from the outside and send it out again. The breathing muscles, however, are strong enough to do their ordinary work for twenty-four hours in the day without ever getting tired. Turn back to the end of Chapter VII. and you will find an explanation of one of the ways in which we breathe. The other I told you is more difficult to understand. It is by working a big muscle called the

Diaphragm,

which forms a partition all across the body between the heart and lungs above it and the liver, stomach, and

intestines below it. The diaphragm is not flat, but bulges upwards. When its fibres contract—that is, get shorter—it bulges upwards less, so that there is more room for the air to enter the lungs above. When the fibres of the diaphragm expand it becomes more bulging again, and some of the air has to go out from the air-spaces in the

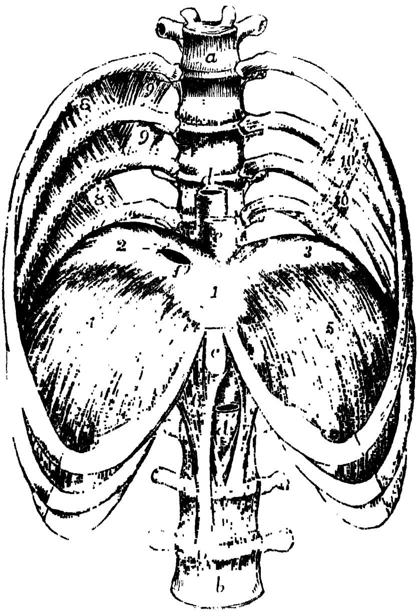


FIG. 67.—THE BODY FENCE (*DIAPHRAGM*).

lungs. Now, if some one of you will explain to me in his own words the two different ways in which we breathe, I will finish up this chapter by telling you a story.

"Oh, I shall die! I can't get my breath!" gasped a thin woman, as she was thrust by a kindly, but rather rough, railway porter into the train just as it was starting. And certainly she seemed to suffer a great deal.

She gasped and struggled for her breath, while her face got quite purple in colour. We fanned her, and opened the window to give her air, and did what we could, and she slowly recovered.

"I ought not to run," she explained, when she got better. "The doctor told me I should never do it. I have had my lungs bad."

"Ah!" thought I, "some of your air cells, of which you ought to have 600,000,000, have got stuffed up by phlegm, and so you have not got enough room for the 250 cubic inches of residual air."

Thus you will see, in order to get more air, the nerves in the lungs were told to carry messages to the oblong marrow (*medulla oblongata*), to tell it to command the muscles to work harder and faster so that more air might be drawn in. This they did, which made the poor woman "out of breath." The blood-vessels could not take up all the oxygen which the purple blood wanted, and so the blood had to remain purple, and that was why the poor woman looked purple in the face, for blood is bluish before it enters the lungs, and is turned red by the oxygen in the air.

Now we have followed the air from the nose to the air cells, and some of it we have left there; but before we say farewell to it I must tell you that the whole lung is enclosed in

A Double-Bag Skin (*Pleura*).

One side of the bag fits closely to the lung, the other side lies against the walls of the chest, while between them is the watery fluid (*serum*) about which you learned when we talked of the coats of the stomach, and which is useful to prevent the two layers of the bag from sticking together.

CHAPTER XLI

THE JOURNEY OF THE BLOOD

WHAT IS THE BLOOD?

ALL through these chapters you have heard a great deal about the blood. What is **The Blood?**

Shortly, it is a warm red fluid. But having said that, you do not know much more about it than you did before, so we must now try and learn something further concerning it.

Now we will imagine that a brave child in the class is ready to have his or her finger pricked. Out will come a drop of blood. Somebody, we will imagine, has provided a clean bit of glass on which the bright red fluid will drop. In a few minutes it will no longer be liquid, it will have turned into a sort of jelly or paste, and its bright red colour will have become a rather dullish brown. That the blood should turn into a jelly, or "clot," as it is called, when it is exposed to the air, is very helpful to us.

Did you ever scratch your hand with a pin, or by treating pussy too roughly, or perhaps the brambles tore you when you were out blackberrying? Quickly the bright red blood came out, but it did not bleed long. Now you know the reason why:—the blood clotted into a sort of paste over the scratch, and prevented any more coming out.

But now we will fancy that a microscope is standing by. The brave child yields another drop of blood, which is quickly put under the magnifying glass of the microscope, and the picture on next page is what you would see. Little round things, something like small biscuits in shape, will be seen floating about in a liquid that looks like pale yellow water. These little round things are called

Little Bodies, or **Corpuscles.**

Blood is made of—

1. **The Blood Fluid** (*liquor sanguinis*).
2. **The White Corpuscles.**
3. **The Red Corpuscles.**

There is a great deal of blood in the body—sometimes there is more than at other times; but if a person is in

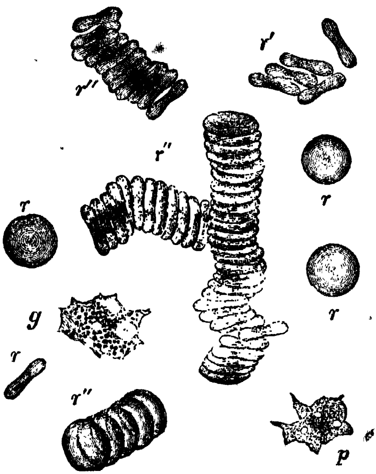


FIG. 68.—BLOOD CORPUSCLES, AS SEEN UNDER A MICROSCOPE.

r, red corpuscles lying flat; *r'*, red corpuscles on edge and viewed in profile; *r''*, red corpuscles arranged in rouleaux; *p* and *g*, white corpuscles.

good health, and could weigh his blood apart from his bones, muscles, organs, and skin, he would find that it weighed about a tenth of all the rest of him put together.

We will first speak of the **blood fluid** (*liquor sanguinis*). It is chiefly water, to which is added certain mineral salts and other matter. It is the part of the blood that has the power of clotting, or forming the sort of paste which, covering a wound, hinders further loss by bleeding.

In this fluid float the **white corpuscles.** They are slightly larger than the red ones; and yet, when I say that, you must still go on thinking that they are smaller than anything that the human eye can see. They are all sorts of queer shapes. If you had a very strong microscope, and were looking down it upon a drop of blood, you would say, as you caught sight of the white corpuscle—

"It is the shape of a pear." And after another few moments you might add—

"No, it isn't—it's like a ball; surely not! it is square—now it has three corners"—for all the while you were watching it, it would take new shapes as it rolled and tumbled about in the watery fluid.

The duty of the white corpuscle in the blood is not fully known, but so far as has yet been discovered, it is thought that its work is that of a gobbling scavenger.

"I never heard of a gobbling scavenger," one pupil told me. "How could any one eat the dust in the cart?"

It is quite true that no one could eat house refuse, and yet to absorb some of the body refuse is the work of the white corpuscle; but what he does with it when he has got it, is so far undiscovered. There are undiscovered lands in the world of science, waiting for some patient and humble Columbus to find them out.

The Red Corpuscle is very tiny. Supposing you wanted to make a pile of them an inch high, you would have to put 140,000, each one on the top of the other, before you could do so. They are round, as you will see in the picture, but they are rather thicker at the edges than in the centre.

"What is their work?" you will, I hope, ask. Their work is

To carry the oxygen from the air into the body.

That is their work. The journey that they, along with the rest of the blood, take, will take much longer to explain.

CHAPTER XLII

THE JOURNEY OF THE BLOOD

THE HEART—ITS CHAMBERS, DOORS, AND PASSAGES

TO-DAY'S lesson will be about

The Heart.

You have all seen sheep's hearts or bullocks' hearts hanging up in the butchers' shops. A human heart is the same shape, and is about the size of the fist of the person in whom it is. If you doubled up your hand to make a fist, you will know that your heart is about the same size. A little baby's heart is about as large as its dear tiny fist; and if you could look inside your father's chest, you would find his heart to be about 5 inches long, 3½ deep, and 2½ broad—that is, about as big as his fist.

Fig. 69 is a picture of the heart.

Before you have finished these lessons you will, I hope, understand all the pipes and vessels that are shown in this picture. Now, you need only look at it to learn something about the shape of the heart.

It contains four rooms or chambers, two on the left-hand side, two on the right-hand side. Those on the right-hand side have no doors leading to those on the left-hand side, but each of the top rooms has a door which leads to the bottom room that lies immediately below it.

Once we were staying by the seaside in a house that was next door to another house which looked exactly like it. So much alike were they outside that sometimes we made a mistake and went into the neighbour's house instead of our own. But once inside we soon found out our error. Outside both houses looked as if each had a room upstairs and a room downstairs, a door in front and a garden door; but inside, though each house had an upstairs and a downstairs room, they were

otherwise quite differently planned. Their doors were in different places and were used for different purposes.

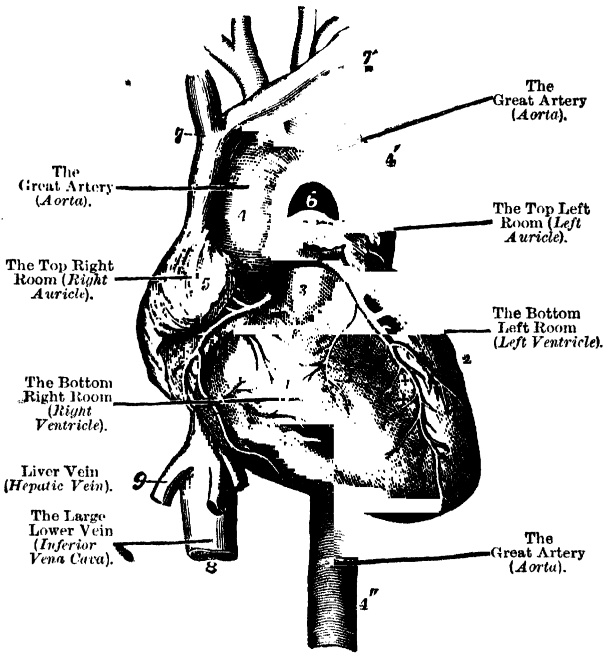


FIG. 69.—THE HUMAN HEART AND ITS VESSELS, VIEWED FROM BEFORE.

1, right ventricle; 2, left ventricle; 3, root of the pulmonary artery cut short; 4, 4,′ and 4″, the aorta; 5, right auricle; 6, left auricle; 7, veins which unite to form the vena cava superior; 8, inferior vena cava; 9, hepatic vein; +, coronary arteries.

"That architect is a clever fellow," said my husband. "He knows what his tenants want, and has built accordingly."

Now the heart is something like these two houses. Each has two rooms and various doors, but each is planned differently, and is used for different purposes.

The heart, too, is like the two houses, inasmuch as no one could go from the rooms of the one into the rooms of the other. The rooms in the heart are called

Auricles. Ventricles.

Or if these two words are too hard for you to learn, you can call them heart rooms, but I should advise you to try and remember these terms.

The top right room (*right auricle*).
The bottom right room (*right ventricle*).
The top left room (*left auricle*).
The bottom left room (*left ventricle*).

Into the top right room (*right auricle*) pours the blood. More and more goes in, until twelve tablespoonfuls are packed into it. Then it flows through a sort of trap door, which is placed in the floor of the top right room (*right auricle*), and enters the bottom right room (*right ventricle*). Gradually this chamber fills, but before we can let it out I must tell you about how the trap door is closed when the bottom right room (*right ventricle*) has got as much blood in it as it can hold.

Opposite are two pictures which will help you to understand it.

While the blood is flowing from the top right room (*right auricle*) to the bottom right room (*right ventricle*) the doors lie down flat as you see they are doing in the left-hand picture, but when the blood has run through them and filled the bottom room (*right ventricle*) these doors float on the top of the blood until they are in the position in which you see them in the picture on the right of the page.

Is it not a beautiful little arrangement?

Perhaps you will wonder why these little flesh doors do not float up higher into the next chamber, and why they stop exactly opposite each other and make a door.

Ah! you did not notice the little cords which bound them to the walls of the heart, and which are just long enough to allow the valves to float up until they touch

each other, and make a firm hard door between the top

Fig. 70.—Diagram showing the Position of the Valves of the Heart while the Blood is passing down.

Diagram showing the Position of the Valves of the Heart when enough Blood has entered the Lower Chamber.

right room (*right auricle*) and the bottom right room (*right ventricle*). The name of these little doors is

The Three Flaps Valve (*Tricuspid Valve*).

These drawings look as if there were only two flaps. That is to make it easier. But on the next page is another drawing which will show you more clearly the three flaps as they would look when they are distended with blood, something, as you will see, like parachutes.

But now we have waited long enough to speak of the valves. If we had kept the blood in the bottom room (*right ventricle*) all the time we have been leaving it there in imagination, we should all have been dead, for it has to pass through both rooms in something like three-quarters of a second.

When the bottom room (*right ventricle*) is quite full,

the muscles in its walls squeeze together suddenly and jerk the blood all out in a moment through a big pipe which is called

The Lung Artery (*Pulmonary Artery*).

But the heart does not stop its labours. No! No sooner has it got rid of all that was in the right lower

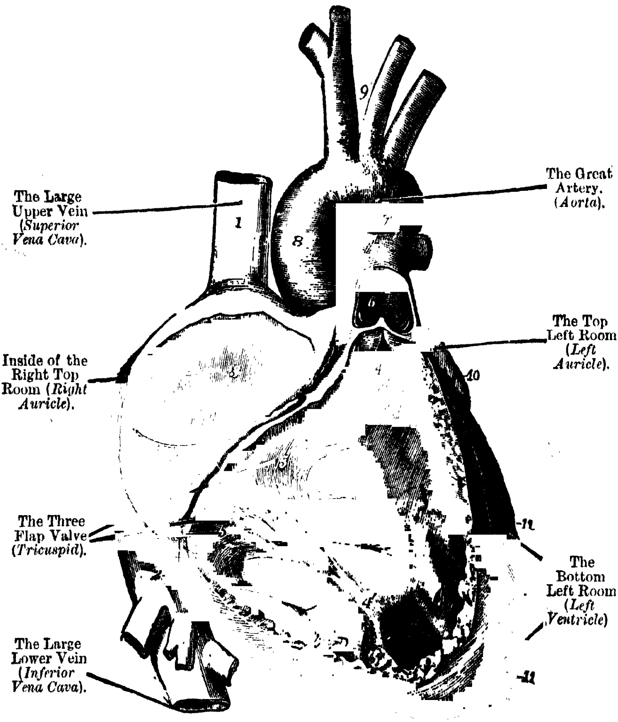


FIG. 71.—INTERIOR OF THE RIGHT SIDE OF THE HUMAN HEART.

1, superior vena cava; 2, inferior vena cava; 3, interior of the right auricle; 4, semilunar valves of the pulmonary artery; 4′, papillary muscle; 5, 5′, and 5″, cusps of the tricuspid valve; 6, pulmonary artery; 7, 8, and 9, the aorta and its branches; 10, left auricle; 11, left ventricle.

room (*right ventricle*) than the upper room fills again. From there it flows into the lower room. The three-flap valve works again, once more the ventricle jumps, once more the twelve tablespoonfuls of blood is jerked on, and so on and on it goes, never stopping until Death does his work, and the heart stops.

I once knew an old gentleman whose three-flap valve (*tricuspid valve*) was out of order. Something was wrong with the little flaps, and they did not work so as to completely close the trap door, and so some of the blood which had left the top right room (*right auricle*), and ought to have been safe in the bottom right room (*right ventricle*), got back again into the upper storey.

Poor gentle gentleman! He was very good and patient, but the consequence was that the heart, in trying to empty itself, had to make a still bigger jerk than usual, and that shook him all over. He could hardly hold a book steady enough to read, and as he much liked learning what men were doing for the government of the country, and what fresh discoveries were being made in science, his life was made sadder and emptier, all because his little three flap valve did not close quite tightly.

CHAPTER XLIII

THE JOURNEY OF THE BLOOD

THROUGH ARTERIES INTO HAIR-LIKE PIPES (CAPILLARIES)

Now we have followed the blood into the lung artery (*pulmonary artery*), but you do not yet know what an artery is. You must learn.

An artery is a pipe very thick and strong. If you could see it, it would look more like a bit of indiarubber piping than anything else. It has three coats—

An outer coat (*areolar tissue*).
A middle coat (*muscular*).
An inside coat (*epithelial*).

Here is a picture of an artery cut through so that you may easily see its three coats.

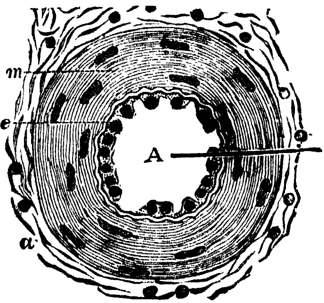


FIG. 72.—TRANSVERSE SECTION THROUGH AN ARTERY, SHOWING THE COATS.

A, artery; *e*, ephitelial lining; *m*, middle muscular and elastic coat, thick in the artery; *a*, outer coat of areolar tissue (magnified 350 diameters).

The outer coat is very strong and rather rough.

The middle coat is made of muscles, and is very elastic. Look how thick it is in the picture compared with the other two.

The inner coat is nearly all made of elastic material, and it is also lined with a very delicate soft skin, so that the blood may have a smooth surface to run over.

Down the big artery rushes the blood, still urged forward by the strong jerk by which it was jerked out of the right ventricle. It runs along the big artery, but that quickly divides into two smaller arteries—one goes to the right lung, one goes to the left lung. They are called

The Lung Arteries (*Pulmonary Arteries*).

These two in their turn divide again into other branches, and they divide into yet smaller ones.

Smaller and smaller become the arteries as they twine in and out of the air passages about which we talked

in the chapters on the lungs; smaller and still smaller as they divide and subdivide, until they are no longer called arteries, but

Hair-like Pipes (*Capillaries*).

Capillaries are very very tiny. They have only one wall, and that is so thin that all that there is in them

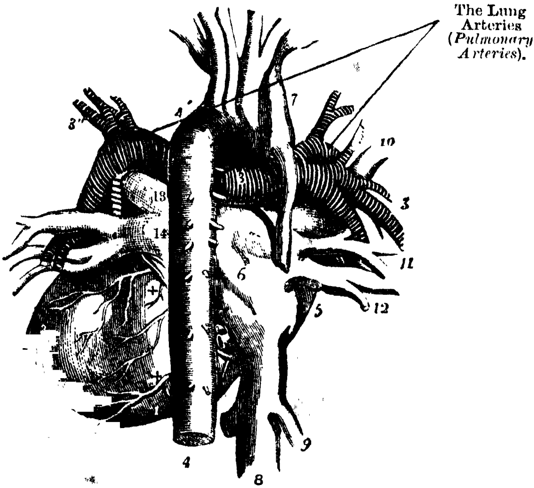


FIG. 73.—THE HUMAN HEART FROM BEHIND

1, right ventricle; 2, left ventricle; 3, 3', and 3", the pulmonary arteries and their branches; 4' and 4", the aorta; 5, right auricle; 6 is placed on the division between the right and left auricles; 7, superior vena cava; 8, inferior vena cava; 9, hepatic vein; 10, 11 and 12, right pulmonary veins; 13 and 14, left pulmonary veins; +, the coronary arteries.

can pass out, and all that is outside them can pass in to them.

In them the blood goes much more slowly. This you will be able to understand if you have ever seen a stream enclosed within narrow banks. Then it was deep and rapid, but perhaps a mile or two lower down

it spread out into a shallow lake, and then it moved slowly.

I once learnt this fact by an interesting experience.

We were driving in California, but we found after we had gone a long way—over forty miles—that we could not reach any house in which to sleep unless we forded a river, as the usual road was broken down.

The river was deep and rapid. It made two glorious waterfalls, as it leapt down nearly 2000 feet over the great rocks of the Yosemite Valley, and then hurried on over its narrow and stony bed.

We stood before it and wondered what to do. The horses, well trained and strong as they were, refused to face it, so rapid and noisy did it seem. The driver told stories of sad fates that had befallen people who tried to urge horses to face rivers of which they were afraid. We could not ford it there, so we turned back and wandered down the stream till it divided into three smaller streams.

Here we crossed, stopping after having waded through one branch to rest the horses before we urged them to ford the other. The water came almost to the top of the horses' backs, but still the stream was much less strong and rapid than it was higher up before it was divided.

The next day we returned to the place again, and found that a mile lower down the stream it was divided again into still smaller channels, and that through them the water was moving quite slowly and gently.

Shut up within narrow walls it rushed swiftly and strongly; divided into three channels it lost some of its force, while it moved but slowly when it had many little beds through which to wander.

The same thing is true of the speed of the blood as it flows through the vessels. The aorta is the large vessel into which the blood goes immediately after it leaves the heart.

Well! it starts in the aorta at a speed of one foot a second. As it passes more and more branches it gets slower, until, in the smallest vessel (*capillary*), it goes

very slowly—at the rate of one inch a minute; but since these capillaries are so very small and short, it only takes about a second to get from one end to the other, and from them the blood enters a small vein. Here it travels rather more quickly, and as it gets nearer the heart, into larger and larger veins, it gets quicker still, but never quite so quickly as when it started in the aorta, because, even in the biggest veins, there is twice as much room for it as in the aorta, and, therefore, the blood travels only half as quickly as it did when it first left the heart.

These capillaries are everywhere, but just now we are thinking and speaking only of those which are in the lungs. There are a great many of them, and they are closely packed all around not only the air cells at the end of the air passages, but also around the air passages or bronchial tubes themselves.

When I tell you of numbers you probably do not take them in, but perhaps if I tell you that some one has said that if all these little hair-like pipes (*capillaries*) which are in the lungs could be fastened together they would reach to America and back, and when I tell you that it takes six days to get to America in the fastest steamboat, you will perhaps be able to understand a little about the enormous number of these tiny vessels into which the one big artery divides.

What is their use?

A very important one. We have followed the blood from the heart to the capillaries around the air cells.

Now we shall see why it went there.

These little air cells are full of oxygen, which you will remember was carried into them by the air after its long and interesting journey. The blood needs oxygen. So the air cells yield up their oxygen, which quickly goes through the thin walls of the tiny hair-like pipes (*capillaries*), and gets taken up by the red corpuscles of the blood; but that is not all.

The blood is full of carbonic acid gas which it does not want. So this gas is sent out through the thin walls of the capillaries into the air cells, and from these

it is returned by the bronchial tubes up into the mouth and out into the air.

Now you know what it is that does this useful work inside the lungs. You know that air went into the body in one condition and returned in another, leaving some of its oxygen there.

You knew that the body absolutely required fresh air to breathe, and you knew that it was poisoned if bad or dirty air was breathed, but you did not know till now what it was that did this useful work. But now you know.

The little red corpuscle inside the tiny hair-like pipe (*capillary*) gathers up the oxygen that is in the air cells. The thin capillary walls let the carbonic acid gas out, and the body has thus got rid of its impurities, and got within it a quantity of blood made clean and fresh and red and strong by the oxygen that is needed.

What is its fate now?

Ah! now begins its work of keeping alive and strong and pure all the organs of the body, but first it has to go again to the heart.

CHAPTER XLIV

THE JOURNEY OF THE BLOOD

THROUGH HAIR-LIKE PIPES, VEINS, AND THE HEART DOORS

In the last chapter we followed the blood as it journeyed through the big artery to the little arteries, and from the little arteries into the tiny hair-like pipes (*capillaries*). There we saw it give out its dirty carbonic acid gas, and take in the nice clean oxygen gas; and then, as I told you, it was ready to "begin its work of keeping alive and strong all the organs of the body," but first it had to go back to the heart.

The blood travelled **from** the heart by an artery.

The blood travels to the heart by a vein.

How does it get from one to the other? By the tiny hair-like pipes (*capillaries*). They are the bridges between the arteries and the veins. Here is a picture.

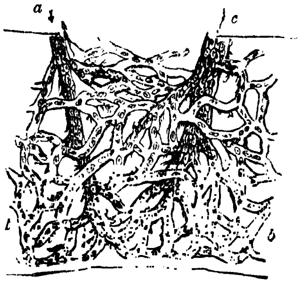


FIG. 74.—CAPILLARY BLOOD-VESSELS IN THE WEB OF A FROG'S FOOT, AS SEEN WITH THE MICROSCOPE.

a, small artery; *b*, capillaries; *c*, small vein. The arrows show the course of the blood.

If you look carefully at this picture you will see that the capillaries branch off from the artery, twist in and out and round about, and then run into another vessel which is called

A Vein.

Now I must tell you that a vein resembles, but in some ways it is quite different from, an artery.

First it has three coats like an artery—

> **The outer coat** (*areolar tissue*),
> **The middle coat** (*muscular*),
> **The lining coat** (*epithelial*),

but each of these three coats is much thinner than those surrounding the artery.

Here is a picture of a vein and its coats.

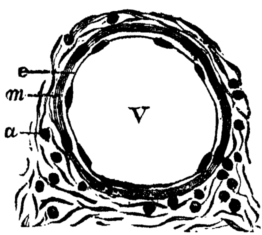


FIG. 75.—TRANSVERSE SECTION THROUGH a SMALL VEIN.

V, vein; *e*, epithelial lining; *m*, middle muscular and elastic coat; *a*, outer coat of areolar tissue (magnified 350 diameters).

The arteries have no pouches or valves, but veins have them, for the same reason that lymphatic vessels do—namely, to prevent the blood flowing backwards.

The blood which, in imagination, we have followed from the right top chamber

(*right auricle*) of the heart, and seen take oxygen from the air, and give up carbonic acid, is now ready to continue its wanderings. It is by this time a bright red colour, and full of life-giving force.

Up and about the capillaries it wanders till all the work it had to do there has been done, and then it is drawn up by a little tiny vein, and by it it is conducted into a larger vein. If it wants to go back it cannot do so, the little pouch valves immediately fill and block the passage, so it has no chance but to go on, and on it goes, until it approaches near to the heart.

By this time all the many veins have joined together, until there are only four, two from the right lung, two from the left lung. They are called

The Lung Veins (*Pulmonary Veins*).

You will see them all marked in Fig. 73, on p. 163, if you study the drawing carefully.

So, at last, all the blood that has been to the lungs to fetch oxygen is brought to the heart and poured into the

Left Top Chamber (*Left Auricle*).

Once inside the heart, does it rest? No; the blood never rests, and it is ready to go on at once. It pours down from the left top chamber (*left auricle*) through another trap-door into the

Left Bottom Chamber (*Left Ventricle*),

very much in the same way as it did when it was travelling through the other side of the heart.

In the trap-door this side there are valves also which float upward as the blood fills it, much like the three-flap valve (*tricuspid valve*) did; but in this left side of the heart it is only a

Two-flap Valve (*Bicuspid Valve*),

and it is also called the **mitral valve**, because when it fills it does not look so much like a parachute as it does like

a bishop's mitre. Below is a picture that is rather difficult, but at the same time very interesting.

You must imagine that the heart has been cut in two. You will not have forgotten what I said about the two houses at the seaside which stood close together and looked alike outside. Now you must imagine that "somebody somehow" has cut off the two top storeys

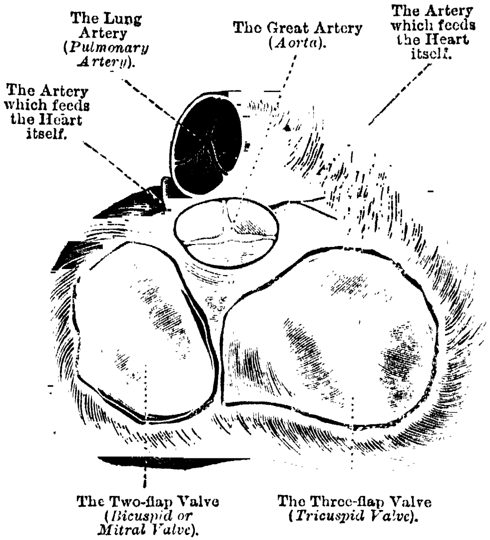


FIG. 76.—THE TOP OF HEART, THE TOP CHAMBERS (*AURICLES*) BEING REMOVED.

and allowed you to look into the bottom rooms and see what everybody is doing inside them.

Have you read Hans Andersen's Fairy Tales? If not, I hope you will choose them the next time you are offered a present, and read and re-read them and find out what they mean; and this advice is offered to any one of any age who has not yet read his stories, for they are full of fun, fancy, thought, and truth. In one tale

he imagines the moon looking through the tops of the houses, and tells us what she saw with her kind eye. For a few minutes you must imagine you are looking into the two bottom rooms (*ventricles*) of the heart, the two top rooms (*auricles*) having been cut off.

You will see the two doors, one leading from the top right room to the bottom right room, covered with its three-flap valve (*tricuspid*), and you can imagine the dirty blood pouring through them.

You will see the other door leading from the left top room to the bottom left room, and you can imagine the clear bright blood rushing through the opening made by the two-flap valve which looks something like a bishop's mitre.

Into the lower left chamber (*left ventricle*) flows the blood, this time quite bright and red, and when it is full the muscles of the heart again give their great squeeze, and jerk it out to go again on its wanderings.

Where is it to go? Not into the lungs again? No. It has been there once and got its oxygen, and other blood is now using those wonderful air cells, and many miles of hair-like pipes (*capillaries*). From the left-hand side of the heart it must go to all the organs to mend and repair them.

CHAPTER XLV

THE JOURNEY OF THE BLOOD

THROUGH THE BIG ARTERY ALL OVER THE BODY

As the heart gives its great squeeze or "beats," as one would say, it jerks twelve tablespoonfuls of blood into the largest artery of the body, which is called

The Great Artery (*Aorta*).

It is a large tube about an inch across, with thick and strong walls. It goes up towards the neck first and

then divides. One branch goes to the right shoulder, another to the left; two branches carry blood to the head to feed the brain, and oh, how full they are now! and how much red blood all of you who are working your brains trying to understand about the circulation are using! for whatever part of the body is at work, that part requires more blood to nourish it and keep it going.

To have anything the matter with the aorta is terrible, for, as you will see, it is the only pipe by which the clean oxygenised blood leaves the heart.

As I have said, this big artery goes up first towards the neck and then arches over and runs down the body just in front of the back-bone. As it goes down the body it gets smaller, because it gives out branches to carry the blood to all parts of the body, until just when it ends at the bottom of the back it divides into two big arteries, one to feed the right leg, and one to carry nourishment to the left leg.

"Tell me something about the circulation of the blood," the teacher once said to a boy who had been studying anatomy and physiology.

"Please, sir," said the lad, "the blood goes down one leg and up the other."

"Very clever of it," said the teacher. "How does it get across?"

But that, neither that boy nor any other could answer, could they? You will know better than that, I hope, for you will not forget that the blood gets taken out of the heart by arteries, and gets taken back to it by veins, and that the tiny hair-like pipes (*capillaries*) are the means by which it is conveyed from the one to the other.

Down the big aorta, and down all its many branches —all called arteries—travels the blood, and the further it goes the more the arteries divide and subdivide, until at last they are again reduced to the tiny capillaries. These have the same delicate thin walls as those about which we talked in the lungs. As they twine in and out of the skin, the intestines, the muscles, the brain,

the stomach, the tongue, the toes, the glands, the throat-chamber, wherever they twine they carry the blood now red and bright and full of oxygen. The oxygen is what these parts of the body want, so the blood yields its oxygen and it enters into the muscles, or the skin, or the tongue, or whatever organ you can think of, and feeds it and enlivens it.

These tiny tubes have, as I have already told you, only one coat, a very thin coat indeed; so fine is it that things can pass through it.

Not only the oxygen but the food carried by the blood passes through to whatever organs need it, and not only does its good material pass out from the blood through these thin walls, but in certain parts of the body where there are the *excreting glands*, of which you heard in Chapter XXV., the waste materials of the body pass out through them. This is one of the very many parts of anatomy and physiology of which there is no room to tell you anything in this little book. If you get to learn all that is in it, it will be very little use unless you also learn that there are many other parts of the subject of which you are quite ignorant.

After leaving the capillaries, what becomes of the blood? The force of the heart which sent it so far is not yet exhausted, and sends it still further on into the small veins, and from them into the larger veins, and on it travels till it enters

The Large Upper Vein (*Superior Vena Cava*),
The Large Lower Vein (*Inferior Vena Cava*),

and from them it is poured into

The Top Right Room (*Right Auricle*),

and this is the place from whence we started when we first spoke of the circulation.

Let us put down the stages of its journeyings :—

1 From the large upper vein (*superior vena cava*) and the large lower vein (*inferior vena cava*).
Into the heart's top right room (*right auricle*).
2 From the top right room (*right auricle*)
Into the bottom right room (*right ventricle*).
3 From the bottom right room (*right ventricle*)
Into the big lung artery (*pulmonary artery*).
4 From the big lung artery (*pulmonary artery*)
Into the smaller arteries (*lesser pulmonary arteries*).
5 From the smaller arteries
Into the hair-like pipes around the lungs (*capillaries*).
6 From the capillaries (*after picking up oxygen and disgorging carbonic acid*)
Into pipes with valves called veins (*pulmonary veins*).
From pulmonary veins

The Lung or Pulmonary Circulation.

Into the heart's top left room (*left auricle*).
From the top left room *left auricle*)
Into the bottom left room (*left ventricle*).
From the bottom left room (*left ventricle*)
Into the great artery (*aorta*).
From the great artery (*aorta*)
Into the smaller arteries, which go into the head, arms, legs, body, &c. &c.
From the smaller arteries Into the capillaries.
From the capillaries (*after disgorging oxygen and food and picking up waste*)
Into the veins.
From many veins Into two veins called—
The large upper vein (*superior vena cava*).
The large lower vein (*inferior vena cava*).

The whole System, or Systematic Circulation.

You will see that on the right-hand side of the page I have put brackets and divided the circulation into two branches.

One has to do with the lungs, where purple blood is made red.

The other has to do with the whole system, where red blood is made purple.

I will finish to-day's lesson by telling you of a brave

boy who saved his sister's life by using his wits and the little bit of anatomy that he had learned.

The boy was about twelve, and his sister some three years younger. They were out playing in a hayfield. The sun shone, the sky was blue, soft fleecy clouds floated

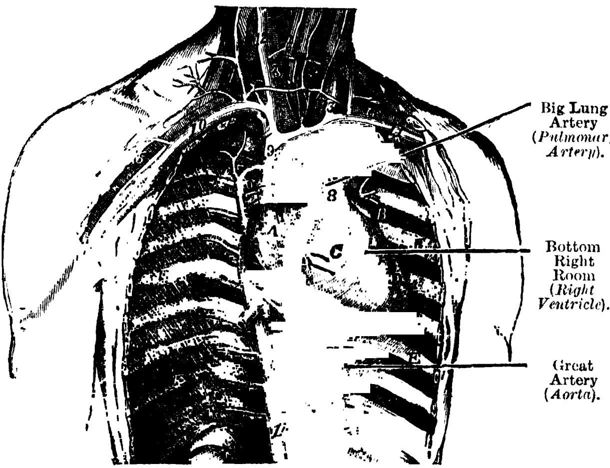


FIG. 77.—GENERAL VIEW OF THE HEART AND GREAT BLOOD-VESSELS OF THE TRUNK.

A, right auricle; B, left auricle; C, right ventricle; D, left ventricle; E, ribs; 1, arch of the aorta; 2, descending aorta; 3 and 4, right and left carotid arteries; 5 and 6, right and left subclavian arteries; 8, pulmonary artery; 9, vena cava superior; 10 and 11, right and left subclavian veins; 12 and 13, right and left jugular veins; 14, vena cava inferior.

overhead, and both girl and boy were having what the Americans would call "a real good time."

While the haymakers went to eat their dinner under the shady hedge at the other end of the sixteen-acre field, the boy took up the scythe to try his hand at mowing. Two or three strokes went well, but at the fourth effort the scythe slipped over the grass instead of through it, and Mary having come too near in her eager-

ness to watch his prowess, received the stroke of the sharp instrument on her leg, just above the ankle.

In a moment she fell with a scream, the blood pouring out all over boot, stocking, and frock as she lay on the ground.

What would you have done? Run screaming across the hot field to fetch the haymakers? If you had, Mary would have been dead before you came back. This her brother knew.

"Don't scream, Mary," he said. "It will be all right."

Then he pulled her leg out, put her flat on her back, and wished that mother was there. But wishing would not bring her, and he fortunately remembered about the blood in the arteries being red and that in the veins being blue, or dull purple red.

Mary's was red; there was no doubt of that; red as red could be, as it came out in little jerks, and made almost a puddle by its quantity.

Off came Jim's necktie, and round the leg he bound it near the wound, but on the heart side of it. Being a boy, he could tie a knot, and so the necktie was tied tight, and the blood stopped flowing, and Mary was saved. Then he halloed, and shouted, and threw stones till the haymakers heard and came and carried the child home, where she lay in bed till the parts that had been cut—the muscles and the artery—had joined together again, and in the meantime the blood had to go by other ways and use more and other capillaries to take it back to the veins.

Everybody was pleased with Jim for saving Mary's life, and Jim himself was not a little proud, I can tell you, though sometimes he gave his teacher credit for teaching him the "lessons."

CHAPTER XLVI

THE JOURNEY OF THE BLOOD

THE PORTAL CIRCULATION

You will not, I hope, have forgotten the lessons about the food, how it was digested, and how the lymph was carried away. All through those lessons frequent mention was made of the blood and the blood-vessels. Now we must revisit

The Stomach,	**The Pancreas,**
The Spleen,	**The Intestines,**

in company with the blood.

In those parts of the body, as the tiny hair-like pipes (*capillaries*) twine in and out, they pick up a great quantity of good food substance. It is so good and rich, that it is not fit to go direct into the heart, and from there into the lungs.

No; it must have certain things done to it first. The liver is ready and fit to do what is required. So instead of the usual course being taken, the capillaries take this rich blood to some special veins, and these veins join together into one vein called

The Portal Vein,

and by this all the rich blood is poured into the liver. Inside the wonderful chambers of the liver it is changed.

Then, when it is ready, it leaves the liver by another vein called

The Liver Vein (*Hepatic Vein*),

and finally joins the other blood in a great vein, the inferior vena cava.

Below is a picture which will show you something about this system of circulation, which is called

The Portal Circulation.

To make this quite clear, we will put down the stages

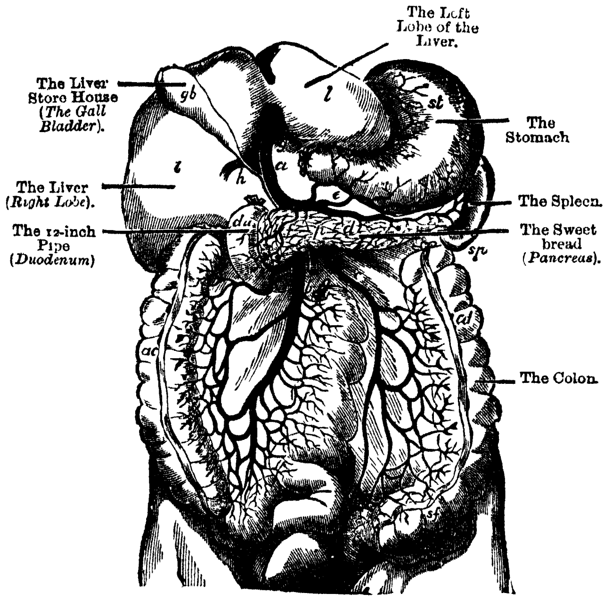


FIG. 78.—THE PORTAL VEIN AND ITS BRANCHES.

l, liver, under surface; *gb*, gall-bladder; *st*, stomach; *sp*, spleen; *p*, pancreas; *du*, duodenum; *ac*, ascending colon, *cd*, descending colon; *a*, *b*, *c*, *d*, *e*, the portal vein and its branches. Portions of the duodenum and colon have been removed.

of the portal circulation as we did those of the lung (*pulmonary*) and whole system (*systematic*) circulations.

From the great artery (*aorta*)	Into the smaller arteries.
From the smaller arteries	Into the capillaries which go round the stomach, pancreas, spleen, intestines.
From these capillaries	Into many veins.
From many veins	Into one vein called the portal vein.
From the portal vein	Into the liver—where changes occur.
From the liver	Into the liver vein (*hepatic vein*).
From the liver vein (*hepatic vein*)	Into the inferior vena cava.
From the inferior vena cava	Into the heart.

The Portal Circulation.

You may have heard people say—

"Ah! poor man, he is bilious, his liver is out of order. See how yellow he looks."

And if you have ever asked any one who knew anything of physiology or anatomy what was meant by that, you would have been told that if the liver was out of order it could not do its work. Its work, you know, is to act upon the substances that have been eaten. But if it is out of order, it cannot do its work properly, and if you give it too much to do, it does sometimes get out of order.

Now you know a little about the circulation of the blood, you will like to hear about the great man who discovered it, William Harvey.

Your teacher will tell you about his noble life and his patience and devotion to the truth, but I will tell you some of the reasons which he gave for thinking that the blood circulated all over the body in the way that we all now know it does. People would not believe in Harvey's discovery then, though he argued it must be so because—

I. If a vein is cut we can stop the flow of blood by tightly pressing it at the side furthest from the heart.

II. If an artery is cut and bright red blood comes out, we can stop it flowing by pressing it at the side nearest to the heart.

If you stop to think a moment, you will see that both of these facts are proofs that the blood leaves the heart by the arteries and returns to it by the veins.

III. In the veins are little valves which are arranged only to allow the blood to travel in one direction.

IV. The pulse corresponds to the beating of the heart. You can easily prove this for yourself. Put your finger on your wrist until you feel a small regular movement. Now bend over till your head nearly touches the floor. After a few moments you will hear a thumping in your head. If you listen to it and feel the pulse in your wrist at the same time, you will soon find out that they both beat together. The reason that you "feel your pulse," as it is called, is because the artery leading to the hand is nearer the surface than most of the arteries.

As the heart gives its great squeeze it jerks more blood into the arteries, and they, being already full, have to expand to take more in until what is there can be hurried along, and this movement you can feel if you put your finger on the artery.

If I were teaching you I should like to be asked questions, and I can imagine some child asking me now, "What makes the blood return to the heart? It is sent out along the arteries by the big jerk that the heart gives; but what makes it return by the veins?"

This would be a question which I should welcome, because it would show thought on the part of the pupil.

Turn back to Chapter XLII. about the Heart. You remember that it is divided into four chambers. Each of these chambers is the same size inside, for each has to hold the same quantity of blood. But the walls of each are very different in thickness. The best way to learn about the heart is to examine a sheep's heart from the butcher's. If you can get one you will see that the walls of the top chambers (*auricles*) both right and left are very thin and flabby. The thick fleshy part of the heart is made up of the two bottom chambers (*ventricles*). Now, if you cut through the heart, you will find that the walls on the right side are not nearly so thick as the walls on the left. By far the greater part of the heart substance consists of the thick walls of the left bottom chamber (*left ventricle*). Now, I wonder if, by thinking, you can find out the reason for what I have just been telling you. Remember what the walls of each chamber of the heart

are for. They are hollow muscles for squeezing the blood out of that chamber. The top right chamber has to squeeze it only a very little way—into the bottom right chamber; the top left chamber only a very little way—into the bottom left chamber: a thin wall of muscle is strong enough to do this in each case, and that is the reason

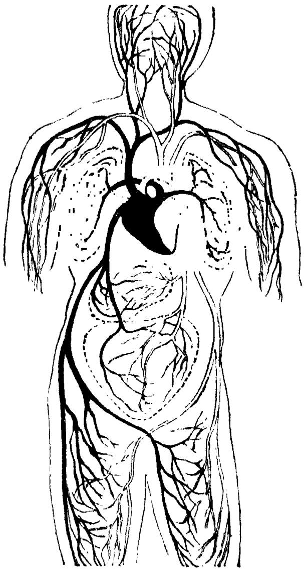


FIG. 79.—DIAGRAM OF THE CIRCULATION (THE VEINS ARE DARK).

why the auricles are thin and flabby. The bottom chambers of the heart have to squeeze the blood not only out of themselves, but all the way through a long system of tubes—arteries, capillaries, and veins—so that it may come back to the top chambers of the heart again; but if you remember what you were taught in Chapter XLII., you will know that the blood from the left ventricle has

to go a much longer journey than the blood from the right. From the right ventricle it goes to the lungs and back again. From the left it goes all round the body. And now, can you tell me why the walls of the left ventricle are so much thicker than all the rest of the heart put together? I think you can; and if so, you will be able to answer your own question with which we started and tell me what makes the blood go back from the wrist, where you feel the pulse, to the heart again. The pulse is caused by the squeeze which the heart gives to the blood, but there is no pulse in the veins. There the blood flows along at an even pace, but the reason why it flows is still the force of the heart's squeeze. Some one asks, Why is there no pulse in the veins? That is a capital question, but it is a difficult one to answer, and there are many questions which it is necessary to leave unanswered in a little book like this.

Fig. 79 is a picture that will show you a little about the heart, arteries, and veins.

CHAPTER XLVII

THE ARMS

THEIR BONES AND THEIR MOVEMENTS

So far we have seen what the body does with the air, food, and water which it gets within it, but we have not yet spoken of the limbs, and it is by their use that most people obtain the food and drink by which they feed their bodies. To-day's lesson will be on—

The Arm and Shoulder.

We have two arms, two hands, two shoulders, as every one knows, but every one does not know that to make these two arms, two hands, and two shoulders there are

sixty-four bones—thirty-two on each side. We will speak of them and their use in order.

The Collar Bone (*Clavicle*).

One end of it is joined to the top of the breast bone (*sternum*). If you turn to page 26 you will see in the picture of the breast bone, just above the figure 1, a little curve slanting upwards. Into that one end of the collar bone (*clavicle*) fits, and the other end is fastened to the shoulder bone. One of the uses of the collar bone is to keep the shoulders broad.

"Don't stoop, children," is often said to you.

"Why not?" a child may ask.

"Because it makes you look ugly, and because stooping children don't give their lungs enough room to grow," is the answer.

Next time some one says to you, "Don't stoop," you will know that the words might have been, "Keep your clavicle extended;" but you will also know that that sort of talk is sometimes used to show people how much the speaker knows, and that then it is vain and unworthy. The more people know, the less they know they know.

One end of the collar bone (*clavicle*), you have just heard, is joined to

The Shoulder Bone (*Scapula*).

This is shaped like a triangle. Most of it is flat and thin, but at the third angle it becomes thicker, and joins to the collar bone.

Fig. 80 is a picture which will show you both the collar bone (*clavicle*) and the shoulder bone (*scapula*), and also

The Upper Arm Bone (*Humerus*).

This is a long bone, and a strong bone. It has one body and two heads, both of which are larger than the bone itself. One head is at the top of the bone, the other is at its lower end.

In this picture the way in which the clavicle and

scapula are joined together looks very confused; it is really very complicated, and we need not trouble our heads about it. The only part of the scapula into which the humerus or upper arm bone fits is the shallow cup marked 4 in the picture.

"Fits," I have said. Well, fits is not quite the word, because if one thing fits another, it generally suits it

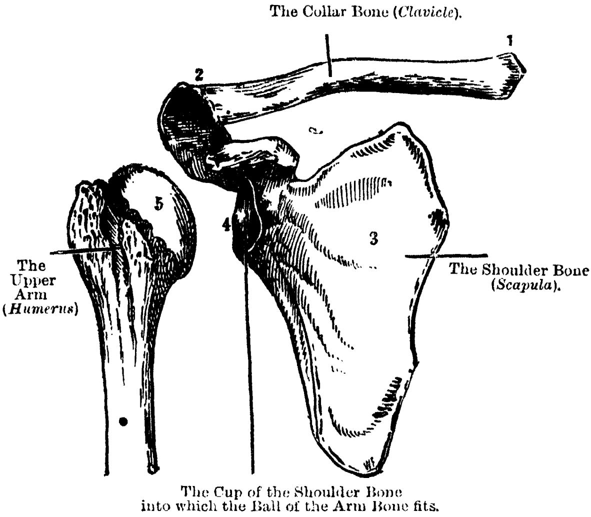


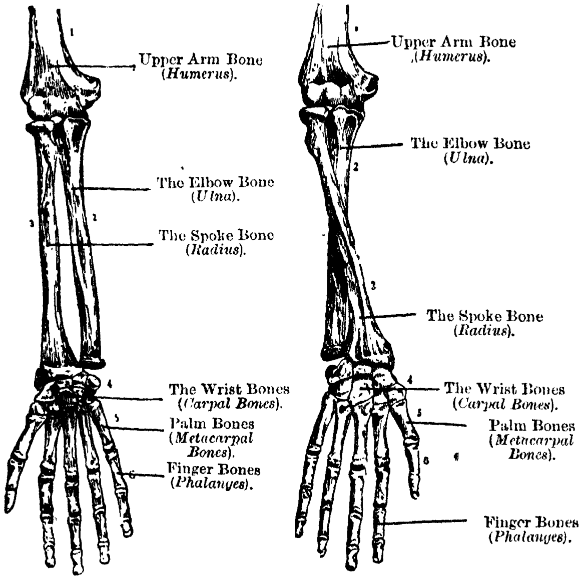
FIG. 80.—THE COLLAR BONE (*CLAVICLE*), THE SHOULDER BONE (*SCAPULA*), AND HEAD OF THE UPPER ARM BONE (*HUMERUS*).

1, clavicle; 2, process of the scapula; 3, blade; 4, glenoid cavity; 5, head of the humerus.

exactly, and it would not be true to say that the head of the upper arm bone (*humerus*) exactly fits into the shoulder bone (*scapula*) cup, for it is much too large for it.

Did you ever play the game of cup and ball? If you play with the big cup end it is easy enough. If once the ball gets into the cup it does not fall out. But if

you play with the little cup end, greater skill will be required, for then the difficulty is not only to catch the ball, but to keep it resting in the little cup, which is much too small. It is the same thing with the ball of the upper arm bone and the cup of the shoulder bone. The ball being big sometimes slips out of the cup.



1. With palm upwards. 2. With palm of hand downwards.

FIG. 81.—THE BONES OF THE RIGHT FOREARM.

1, humerus; 2, ulna; 3, radius; 4, carpal bones; 5, metacarpal bones; 6, phalanges.

"His arm is broken, I fear," said a young nurse who had volunteered to go and tend the sick wounded in the Franco-Prussian war.

"No, I think not," said the doctor; "not broken, only dislocated."

"Pull! then, doctor, pull! pull him out and he'll

come in! I've seen many a one done," said the poor fellow, and then fainted with the pain, caused by the shaking waggon and the loss of blood from a flesh wound in his leg.

"What does he mean?" whispered the young nurse, dreadfully frightened.

"The ball has slipped out of the cup, and gone beyond it," answered the experienced nurse. "It must be pulled down till it gets below the rim of the cup, and then it will slip in again. Don't be frightened," she added kindly, for she was sorry for the girl whose generous kind heart had made her volunteer to do work about which she knew nothing, and which frightened her so much.

One of the advantages of the ball and cup joint is that it enables the arm to be moved in any direction. Try, and you will see that you can move that limb up and down, backwards and forwards, and you can twist it round like the arms of a windmill.

The picture opposite will, I hope, explain to you the positions of these bones and other bones about which you will hear in the next chapter.

CHAPTER XLVIII

THE ARMS, WRISTS, AND HANDS

THE upper arm bone (*humerus*) has, as you know, two heads. The top head fits into the shoulder bone cup, its lower head fits on to two bones; the larger of these two is called

The Spoke Bone (*Radius*).

It is called this queer name because it is supposed to resemble one of the spokes of a wheel. It also, like the upper arm bone (*humerus*), has two round heads. In its top head is a small shallow cup. Its lower head is fastened to the bones of the wrist.

The name of the second bone, which bears the upper arm bone (*humerus*), is

The Elbow Bone (*Ulna*).

The elbow bone has only one head, and it fits into the lower head of the big bone above it by a kind of hinge, which is like the hinge of a door, and does not allow the bone to bend backwards.

Try, and you will see that your arm will not bend backwards at the elbow joint.

Now we will make a little experiment. Let one child lay his arm flat on a table, the inside touching the

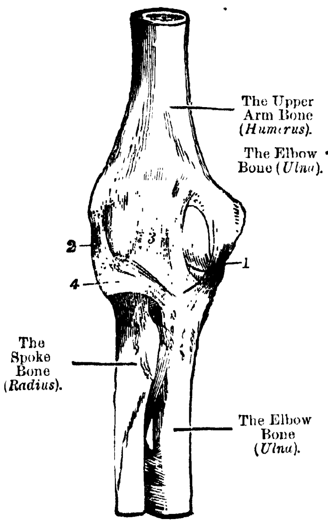


FIG. 82.—THE LIGAMENTS OF THE ELBOW-JOINT, FROM THE FRONT.

1, 2, 3, and 4, the ligaments.

FIG. 83.—THE LIGAMENTS OF THE WRIST.

1, 2, 3, 4, 5, the palm bones (*metacarpal bones*).

wood, but with the palm of the hand turned upwards. If we could suddenly skin that child and strip off his muscles, with all their marvellous arrangements of nerves

and blood-vessels, we should find the spoke bone (*radius*) and the elbow bone (*ulna*) lying side by side, the one straight with the other. Now give the order,

"Turn the hand till its back is outwards and the palm near the wood."

He begins to obey. Let us see what happens.

The elbow bone (*ulna*) does not move, but slowly the lower end of the spoke bone (*radius*) turns round and rolls over his neighbour, and being fastened to the wrist the hand turns also. You will see this clearly in Fig. 81, on the right hand of the page.

We must now speak of

The Wrist Bones (*Carpal Bones*).

There are eight of them in all. Two rows of four in a row. They are all bound together by binders or ligaments.

"What are binders or ligaments?" I fancy I hear a pupil ask. "They are strong, white fibrous bands which bind the bones together. Being more or less elastic, they allow of the necessary freedom of motion to the bones, and at the same time protect the joints from external injury and tend to prevent dislocation."

Opposite is a picture of the eight wrist bones bound together by the binders or ligaments.

On the right-hand side of the picture you will see the ligaments of the wrist; and on the left you will see the upper arm bone (*humerus*), and the elbow bone (*ulna*), and the spoke bone (*radius*), all bound together by their binders or ligaments.

Bound to the elbow (*ulna*) and spoke bones (*radius*) are the **wrist bones** (*carpal bones*), and they, in their turn, are fastened by their ligaments to the

Palm Bones (*Metacarpal Bones*).

Of these there are five. Unless you look very carefully at the picture, you will think that they are only the beginning of the fingers and thumb. So they are, but instead of being each separate they are all bound together by the flesh and skin.

It is quite easy to feel the palm bones. Try, and you will be able to trace each one from the wrist to the

Finger Bones (*Phalanges*).

We have four fingers and a thumb, but it takes fourteen bones to make them—three in each finger and two in the thumb.

In this picture you will see each one clearly marked.

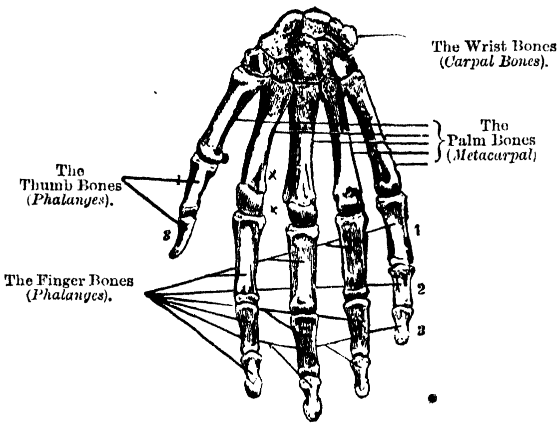


FIG. 84.—THE RIGHT HAND BEFORE.

The English have introduced many good things into India, among them the game of cricket. It is very curious to see black boys wearing very few clothes running with a ball and fielding as carefully as any English lad could do. They catch the cricket ball, and it goes "crack" into their palms, just as it does at home.

Why does the blow not break the hand?

Because it is made of twenty-seven bones, and the many, each yielding a little, enable the hand to resist shocks which, if it were only made of one or two, would break it to pieces.

CHAPTER XLIX

THE LEGS

The legs and feet very much resemble the arms and hands; so, believing that you have studied the last chapter carefully, there will be no need in this one to dwell so long on the mere bones.

When we talked about the body barrel (*pelvis*), I told you about the cup into which the ball of the leg bone put its head, and you also learnt that the legs were like the two piers of an arch on which the whole weight of the body rested. The name of this bone is

The Thigh Bone (*Femur*).

As people have two legs, they also have two thigh bones, one in each leg, but I will speak only of one leg, and you will know that what is true of one is also true of the other.

The thigh bone (*femur*) is the largest and heaviest bone in the body. It reaches from the thigh to the knee. The ball head is bound into the cup by the strongest ligaments. This cup is not so shallow as the cup in which the big bone of the upper arm (*humerus*) rests, and the consequence is that the leg cannot move so easily as the arm is able to. Try it, and you will see that you can swing your leg forward, backward, and sideways, but you cannot throw it up over your head.

When I was young a great deal of attention was paid to what was called "young ladies' deportment," and I used to be sent with many other girls to learn how to move my limbs.

"Stand on one leg," the teacher used to say, "and swing the other."

We used to try.

"More," she would shout. "More! young ladies, move your balls—don't let them stick."

I never understood what she meant, but now you do. She meant move the thigh bone (*femur*), make it rotate as much as its ligaments allow it in its cup (*acetabulum*).

Each thigh bone (*femur*) starts about a foot from the other, but they slant inwards until they are able to touch each other at the knee. Here begin the two next bones of the leg. One is called

The Shin Bone (*Tibia*).

It has received its Latin name because it was thought to look like a flute, but I think it must have been a very queer sort of flute, and if you look at the picture and try to guess which of the bones was called the flute, I don't think any of you would guess right at the first guess. It is true that, like a flute, all these bones are hollow, though they, unlike it, contain marrow.

The shin bone is placed near the skin, which explains a slang expression often used.

"He has barked his shins," it is said, to explain the fact that the skin has been scraped off the front of the leg. As the bark of a tree is its covering, so is the skin the covering of the leg, the shin bone of which lies near the surface. Behind it stands its twin brother, which is called

The Buckle Bone (*Fibula*).

Like many other twins who pass their lives side by side, these two bones are very different.

Here is a picture from which you will see that the shin bone (*tibia*) is much larger than the buckle bone (*fibula*).

In olden days gentlemen wore stockings and knee breeches, which they buckled on with smart buckles. You will see them in museums. Some are made of gold or silver, while I have seen others beautifully decorated with coloured enamels, diamonds, or precious stones. The buckle bone gets its name from this fashion or dress, for it lies immediately below where the smart men fastened their smart breeches.

You will remember that there is an arrangement in

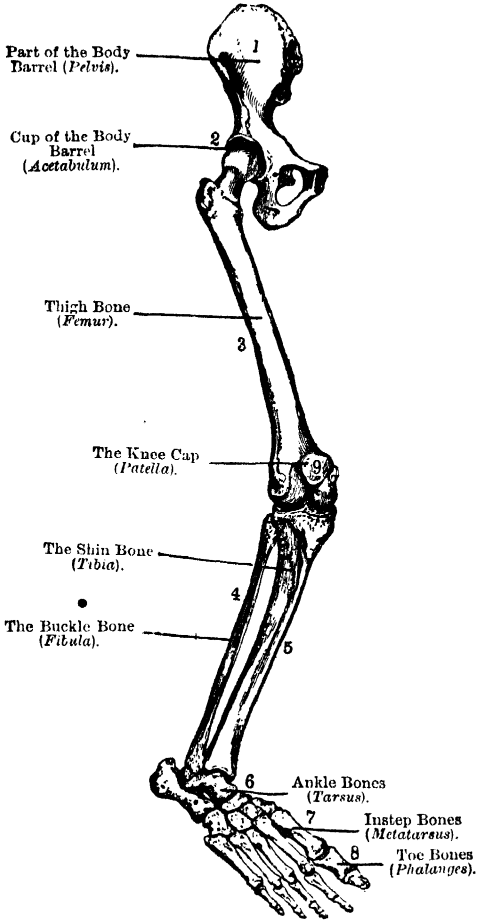


FIG. 85.—THE BONES OF THE LOWER LIMBS.
1, os innominatum; 2, acetabulum; 3, femur; 4, fibula; 5, tibia; 6, tarsus or ankle; 7, metatarsus; 8, phalanges of toes; 9, patella.

the arm to enable the hand to turn. This does not exist in the leg. The buckle bone (*fibula*) is fastened to its twin both at the top and bottom, and the shin bone is joined to the ankle at one end, and to the thigh bone (*femur*) at its opposite extremity.

During one holiday my husband and I drove about lovely Cornwall. We had a small two-wheeled cart, so near to the ground that we could jump out to pick the wild-flowers or drink of the clear brooks. Our pony was old, but was believed to be sure-footed. The hills are very steep in Cornwall, and one day when we were descending an unusually steep one, the old nag slipped on a loose stone and fell with a crash.

"He has broken his knees, I fear," said my husband, and he hastily got out to see.

"Poor beastie!" I said, "I hope not."

"We will hope it is only the hair, but I am afraid it is more—it was a heavy fall," I got as a reply.

However, we found he had done neither, and was only so vexed and annoyed at finding himself tripping that he sulkily objected to rising. When it is said of a horse, "He has broken knees," it only means that the hair and skin are broken; but if the words are used of a human being, it is a much more serious matter.

CHAPTER L

THE KNEE-CAP—THE FEET

JUST where the shin bone (*tibia*), with its twin firmly attached to it, joins the thigh bone (*femur*) a single bone is put. It is called

The Knee-Cap (*Patella*).

It is very important that joints should not receive blows or shocks. We have all watched a tiny baby when it is trying to walk. How often it falls! First it tumbles on its chubby hands, but their many bones

help them to bear the shock of the fall. Then it drops on its knees. The concussion with the hard floor might damage the joints of the thigh bone (*femur*), the shin bone (*tibia*), and the buckle bone (*fibula*), so over them is put this knee-cap, which protects them.

Beautiful are the arrangements by which it is kept in

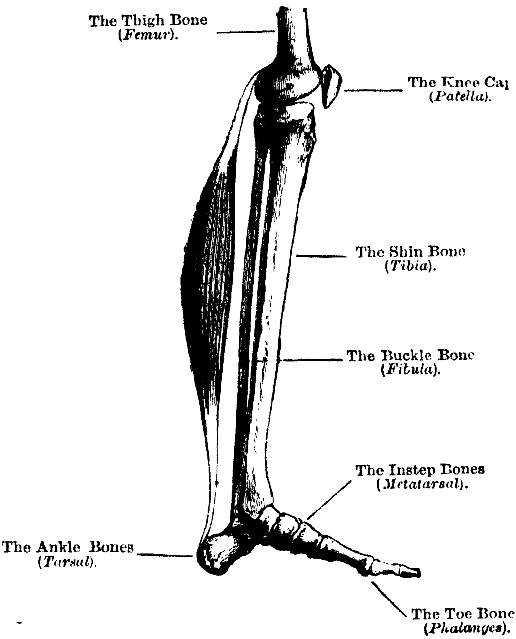


FIG. 86.—THE BONES AND LARGE MUSCLE OF THE LEG.

its place; but they do not like being continually pressed, and this is the reason why women who scrub a great deal should always kneel on something soft, so that the knee-cap, which you see is a little curved in shape, should not be squeezed against something quite flat.

The bottom of the shin bone (*tibia*) is fastened to one of

The Ankle Bones (*Tarsal*).

There are seven ankle bones, and you will be able to see their positions from these pictures.

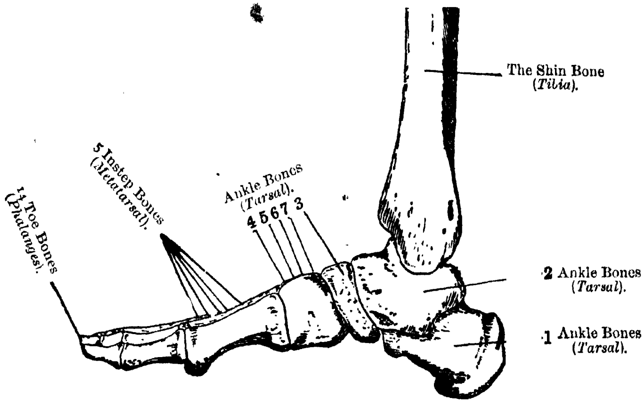


FIG. 87.—THE BONES OF THE FOOT, VIEWED FROM THE SIDE.

The largest of the ankle bones makes the heel. The others form the ankle and part of the sole.

Just where the seven ankle bones (*tarsal*) leave off the

Instep Bones (*Metatarsal*)

begin. There are five of them, and they, like the palm bones in the hands, are the beginning of the toes.

Fig. 88 will explain clearly the bones of the foot.

The continuation of the instep bones (*metatarsal*) are

The Toe Bones (*Phalanges*).

There are fourteen altogether, divided among the five toes.

"Which do you think is the thumb of the foot?" I asked the children in a class.

"The little toe," one child said. "It is the shortest, like the thumb."

"The foot has no thumb toe," another answered.

Both were wrong; for the big toe is the thumb of the foot, which, in another sense, "has no thumb toe," because the big toe cannot move about and stand opposite to the other toes as the thumb twists about in front of the fingers. Very like fingers are the toes—in monkey bodies more so than in human bodies—but

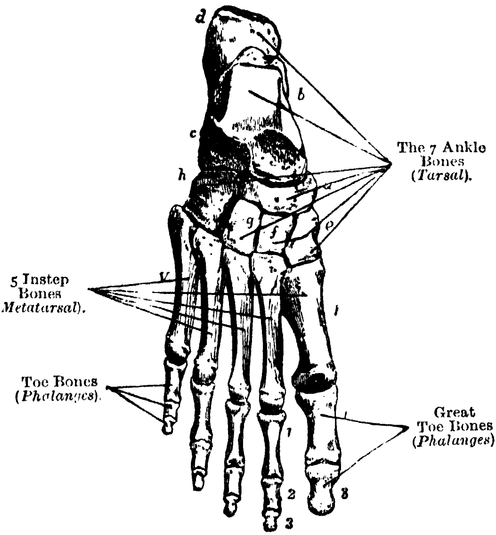


FIG. 88.—RIGHT FOOT, VIEWED FROM ABOVE.
a, *b*, *cd*, *e*, *f*, *g*, and *h*, the tarsal bones; I to V, metatarsal bones; 1 and 3, phalanges of great toe; 1, 2, and 3, phalanges of second toe.

they enough resemble them to make the French people name the toes "the fingers of the feet."

Look at the pictures and you will see that the bones on the inner side of the foot form an arch. There are several reasons for this. In the south of France the women walk a great deal, bearing on their heads large baskets of lemons. The great weight sometimes causes the ligaments of their feet to give, and the arch drops and they become flat-footed.

"It is my foot, dear lady, the doctor says, but I feel it in my head," was said by a dark-eyed, rich-skinned Italian girl in her pretty *patois*, and though it sounds funny, it really was the truth. Her work had been to carry large baskets full of yellow lemons on her head, and the weight had injured the arch of the foot. One of the uses of the arch of the foot is to prevent the body being jarred by every step. If the arch has sunk and the foot falls flat, the jolt is felt all over, but especially in the head, which is the seat of so many of our finest powers.

CHAPTER LI

THE JOURNEY OF A FEELING

THE TOUCH CORPUSCLES

How much we feel! Every one of us feels a great many different sensations. We all feel if a pin pricks us, and we also feel heat and cold, hunger and thirst, pain, pleasure, or fatigue; and some people feel strong or weak, sorry or glad, young or old.

"I felt so young, so strong, so sure of God," says the girl Aurora Leigh, about whom Mrs. Browning writes, and she felt she must use herself to help the sick and sorry world.

"I feel done-like and weary most days," was the complaint of a sad old woman who was tired after her life's battle with illness and poverty.

"I feel a pin running into me," you might say, and it is of this last sort of feeling about which we are going to speak in to-day's chapter. In Chapter I. you will remember that we imagined a pin that started travelling, and you learnt something about what it saw.

Amongst the other wonders which it came across were some tiny hillocks (*papillæ*) made of the true skin (*dermis*), which ran up in peaks in and out among the colour cells

(*Malpighian cells*). These hillocks (*papillæ*) contain nerve fibres. Here is a picture of the hillocks (*papillæ*).

FIG. 89.—THE HILLOCKS—PAPILLÆ OF THE SKIN FROM THE PALM OF THE HAND. MAGNIFIED 60 DIAMETERS.
Upper skin (*epidermis*) has been removed.

Some of these nerve fibres are quite simple, others divide or subdivide, while many of them have little oval bodies fastened to or scattered among them. These little bodies have a difficult name, but you may call them

The Feeling Cells (*Pacinian Bodies*).

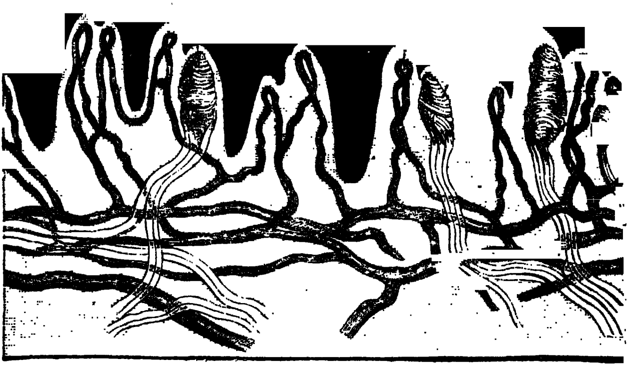


FIG. 90.—PAPILLÆ.

This picture will show you the way in which they lie amidst the hillocks (*papillæ*).

To each of the little cone-shaped things you will see

one of the messenger nerves is attached, and no sooner does something touch them than the news flies to the brain, and we feel and know that we have been touched.

Some smaller feeling cells are called

Touch Corpuscles (*Tactile Corpuscles*)

In some parts of the body feeling is more acute than in other portions. For instance, the lips, the tips of the fingers, the tongue, or the palms of the hands are much more sensitive to being touched than the back or the thigh. This is because the touch corpuscles (*tactile corpuscles*) are close together there, while over the duller places they are farther apart.

Look at your hand; can you see the little lines in it going this way, and turning in that direction? And do you notice how inside the hands, at the ends of the fingers, the little lines are placed round and round in circles, ending in the middle with quite a tiny one?

Look now at the back of your hand. There you do not see the lines going in circles or wavy figures, but the skin seems to be in small wrinkles or smooth star-like figures. If you look at the skin of the sole of your foot, you will find the lines much more plainly marked, and larger than those on your hand. In other parts of the body the skin is quite smooth.

In or among these lines, always hidden away under the upper skin (*epidermis*), are the nerves of feeling, and in these parts the little lines show that they are present.

In different places these touch corpuscles (*tactile corpuscles*) have different powers. Some have the capacity for rapidly feeling heat; these are chiefly placed on the cheeks, the eyelids, and the elbow.

"Why do you put your iron near your cheek?" asked the squire's daughter, when paying a cottage visit.

"To try its heat, my honey," replied the burly, good-tempered washerwoman.

"I should try it with my hand, I think," said Miss Dainty; "it might scorch my face. Why don't you?"

"Well, it's our custom, missy, to put it to the cheek,

though I daresay other parts would do as well," was the kindly but unscientific reply.

"No, it would not," some one could have answered; "experience has found out that the cheek has greater powers of feeling gradations of heat, and science has found out that this is so because the touch corpuscles there are numerous and peculiarly sensitive to that form of feeling."

Did you ever wash your face in water that was too hot? If so, you will remember that your cheeks suffered, but not so much as the eyelids. In these delicate eye-coverings are placed the touch corpuscles that object to heat, thereby doing their duty of protecting the eye, which is easily injured by scorching or becoming too hot.

A little time ago a sad accident occurred in a rich man's house. Every night the baby was bathed in warm water, and much he enjoyed his tubbing, crowing and kicking with delight. To make sure that it was exactly the right heat, the thermometer was always put into the bath before the baby was allowed to bathe. But one day it got broken, and the heat had to be guessed at. "I think that is about right," said nurse, and she popped him in. Poor little fellow! his screams were dreadful. Quickly she scrambled him out and rolled him up in the soft towel, but the mischief was done. His soft skin was scalded, and he suffered sadly.

"Why did you not try the heat of the water with your elbow?" asked his mother, angry in the midst of her grief.

"I tried it with my hand, which was as good," replied the nurse.

"Oh no! it wasn't, the elbow tests heat better," answered the lady.

She spoke truly, and you now know why.

Inside the body the parts that feel heat most are the gullet and the stomach. What a wise arrangement. If this were not so planned we should probably pour things down our throats so hot that they would injure the delicate coats and glands inside the stomach, by the aid of which the food is digested.

The touch corpuscles (*tactile corpuscles*) are more numerous at the tip of the tongue than anywhere else. The grown-up Japanese people do not kiss one another; they say it "is a foolish foreign habit." They only kiss their tiny little children, and their kisses are very queer ones, like so many of their ways. The mother puts out the tip of her tongue, the little child does the same; both touch, and that is their kiss. They kiss, you see, with that part of their bodies where the touch corpuscles are most numerous. After the tongue the tips of the fingers are most sensitive.

Blind people often read with their fingers, which they pass over letters which have been raised in the printing. If you tried you could not feel the difference between the letters, but they have cultivated their sense of touch until it has grown, and become both much stronger and more delicate.

Once I knew an old blind man who had lost both his arms, but he was very intelligent, and as he had no fingers with which to read, he learned to do so by his lips, for they, you know, are well supplied with touch corpuscles. The nose also has a good share.

My brother was often naughty, and one day he proposed we should tickle grandpapa when he was asleep, so he began with a straw. It was not much fun, for he slept peaceably on till his nose was touched, then he jumped up with a start.

"Heigh! yes! what is it? Who is there?" he said, while we stooped low and hid behind his big chair.

It was very naughty, but you have learnt with its help that the nose has under its skin many touch corpuscles (*tactile corpuscles*). The sense of touch serves to us as a protection. Without it the body would get into many dangers and heed them not.

"I feel nothing when I am painting," wrote a great artist. "A snake may crawl over my foot, a bird may sit on my shoulder, and I would not know it."

Few of us get quite so unconscious as he did, for most of us are conscious of a touch, and this saves us from things hurtful or disagreeable.

CHAPTER LII

THE JOURNEY OF AN ODOUR

THE NOSE

In some parts of the south of France and Italy there are whole fields of roses. They are grown so that scent may be made. If you were to drive through them you would say, "I am glad I have a nose. How delightful this is!" In China the smells are so nasty that some English people stuff cotton-wool into their nostrils when they walk out. We were not told this before we went, and the consequence was that we could not see half that was interesting in Canton, because the bad smells made us ill and unfit to enjoy.

"What is a smell?"

"We all know what a smell is when we smell it," some one may reply; but that will not be the answer to my question.

A smell is the knowledge in the brain that certain things have touched certain parts of the body.

"Certain things! what sort of things?" you may ask, and I shall reply, "Any sort of thing, providing either that it is so small that it can float with the air up the nostril or turn itself into a gas that mixes with the atmosphere."

Let us follow this. There comes a smell of cooking from the kitchen, because parts of the meat or greens or cake are separated by the heat from the things themselves. They float in the air and enter the nose. There is a horrid smell from the drain, and the reason is the same. Certain nasty dirty things, after having been thrown down the drain, have turned themselves into gases, have mixed with the atmosphere, and with it enter the nose. All around us are smells—nice scents,

such as roses and carnations give; disagreeable odours, such as chemical factories or gasworks cause.

But how do we know that they are there? We cannot see, hear, or touch them. It is

The Nose

which tells us of their existence, for it is the organ of smell. It is triangular in shape, partly made of bone, partly of cartilage, and can shortly be described as consisting of many chambers or rooms—two front doors, two back ones—and two long passages, in which stand rows of small guards, whose sole duty it is to keep out intruders.

Before I describe the journey of an odour, you must look carefully at this picture of the nose, to which I shall often refer.

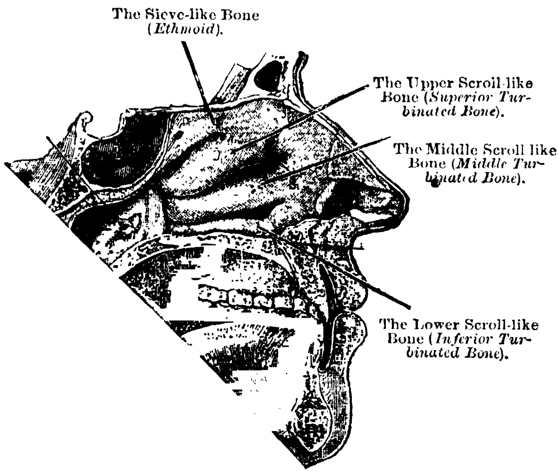


FIG. 91.—THE INSIDE OF THE NOSE AND SOME OF ITS BONES.

If you turn to Chapter XIII. you will be able to recall not only the fact that seven of the fourteen bones of the

face have to do with the nose, but also their names and some of their uses.

It is a wonderful place this house of smell, with exquisite rooms and all sorts of marvellous contrivances. In it are the scroll-like bones (*inferior turbinated*), which, twisting in and out, make many rooms. It is the nose bones (*nasal*), which form the outer walls of the chambers, while their roof is made of our old friend the sieve-like bone (*ethmoid*), and in the floor we find another acquaintance, no less a one than the bone that formed the roof of the mouth (*palate bone*). The little tear troughs (*lachrymal*) run down the sides of this home of smell, and the ploughshare bone (*vomer*) divides the wall passage exactly in half. Each passage is called

A Nostril.

And now, in imagination, we will follow an odour in the air until you know that you smell a smell.

First, the tiny particles approach the door of the passage and enter by one of the nostrils. It finds it lined with tiny hairs, which, like those in the hearing passage (*auditory canal*), serve as a sort of screen to keep flies and dust out, or to prevent them going farther up the nose into the delicate chambers that lie farther back. These are the guards.

If the incomer is an intruder, they bend forward and resist its entrance; but if it is only a smell, they stand still and allow the tiny particle or invisible gas to go on undisturbed. On it travels through a little room, round a corner, down a passage, until it reaches the chamber made by one of the scroll-like bones (*middle turbinated*). Up to now the odour had travelled with the rest of the air which naturally went into the nose on its way to the lung, but now it leaves the rest of the air, continues its path, and goes out into the throat chamber (*pharynx*) by the two openings which are called

The Back Doors (*Posterior Nares*).

Before we follow the journey of the odour farther I must show you a drawing.

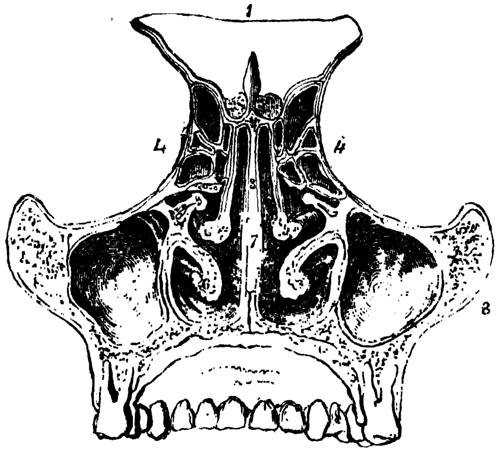


FIG. 92 —SECTION OF THE NASAL CAVITIES, SEEN FROM BEHIND.

1, frontal bone; 3, perpendicular plate of the ethmoid bone; 4, ethmoidal cavities; 5, middle turbinated bone; 6, inferior turbinated bone; 7 vomer; 8, malar or cheek-bone.

You will see two tiny figures, 5 and 7, nearly in the centre of the drawing. In the little channel that is shown between these two figures, the air travelled until it reached the opening that leads into the queer-shaped room against which is the figure 5. Then the odour with the rest of the air went into this room.

"What did it find there?"

A fairy surprise, for no sooner had it got inside the room than it found itself entangled in a fringe of hairs; and yet the word hairs hardly describes the fringe, for each string is finer than any hair could possibly be.

"Could the odour get out?"

Well, I don't know that it wanted to, but it could not do so if it wished. Each time it moved, and each new particle that came into the chamber, struck another and another of these tiny hairs, which, nearer the roof of the

chamber, joined together. When joined they united with others, until altogether they formed one nerve which is called

The Smell Nerve (*Olfactory Nerve*).

It was this nerve which carried to the brain the news that little particles of a sweet rose or putrid meat had touched their ends, and you **knew** you had smelled a smell.

We have spoken of the roof of this smell house. Through it the news travelled, for you will remember the roof is formed by the sieve-like bone (*ethmoid*) which, as its name shows, has many holes, and these allowed the nerves to pass.

This picture will explain to you a little about the smelling nerve (*olfactory nerve*) as it spreads out in the

Smell Chamber (*Olfactory*).

It is the branching nerve near the top.

FIG 93.—NERVES OF THE NOSE (*OLFACTORY*).

"Oh! what a nice smell of hay! Let us sniff it up," a farmer's wife said to a party of little London children who had come down to stay with her.

"I can't smell it," said a poor pale mite; "I have got a cold."

"I—I—I *shan't* sniff, for I don't want to sm—sm—smell it," stuttered one ill-mannered boy.

"You will lose a pleasure then, and punish only yourself," said a teacher who was there. But I expect you will want to know why people can smell more by sniffing in the scent.

Let us try the experiment. Close your lips firmly and draw a long breath. All the air will be compelled to go through the nose passages, which will be fuller than usual, so more air will find its way into the smell chamber (*olfactory*) until it is full to the roof. On its roof are still more little nerves, and these are extra acute, so if the odour reaches them the brain hears still more about it.

But cold prevents people from smelling.

"My nose is stuffed up," they say, and it is true the cold makes the wet skin (*mucous membrane*) swell and discharge so much that the opening into the smell chamber (*olfactory chamber*) is stuffed up, and the odours cannot get in, but have to pass on and out of the nose with the other air.

"Ugh! I have swallowed a smell. It went right into my lungs," a gentleman said who had been to look at dustbins and drains to try and find out why so many children were ill in a certain alley.

What he meant was that the smell had gone past his smell chamber (*olfactory*) into his throat chamber (*pharynx*) and down into his lungs.

Alas! it was too true. The tiny unwholesome particles were picked up by the blood-vessels around his lungs, and he died ten days afterwards. And his is not the first noble life that has been sacrificed because people will not be clean and obey the laws which Moses gave to the Jews and to all others besides.

CHAPTER LIII

THE JOURNEY OF A WORD

THE VOICE-BOX (*LARYNX*)

One of the great differences between human beings and other animals is that the former talk, the latter are speechless, though all, or nearly all, of them make some sound. The beautiful instrument that enables mankind to speak is called

The Voice-Box (*Larynx*).

It is placed immediately at the top of the windpipe, indeed, it may be said to be the enlarged top of the windpipe itself.

There are two pictures of it on page 208.

To understand the pictures you must recall the facts about the two first bands of the windpipe. The top one is named **the shield ring** (*thyroid*). You can see the front of it in any boy's throat. It pokes out, and is then called Adam's apple.

Where it got this funny name I can't say, but I have heard that it was so called because of an old legend which says that Eve ate her apple, enjoyed it, swallowed it, and thought no more about it, but that a piece of Adam's apple stuck in his throat, and so this queer cartilage, which looks like a three-cornered bit of apple, got called Adam's apple. It goes but half-way round the windpipe. Standing immediately above it is a small bone called

The U-shaped Bone (*Hyoid*).

It is easily found in the picture.

The second ring (*cricoid*) is, as you will remember, the ring that goes quite round the windpipe and refuses to move out of the way when the gullet requires more room.

Between these two rings there are two cartilages of a very curious shape. They are the special friends of the second ring (*cricoid*), and do nearly everything that it does.

If my readers are boys, they have, of course, played "Follow my leader," and if they are girls, I hope they

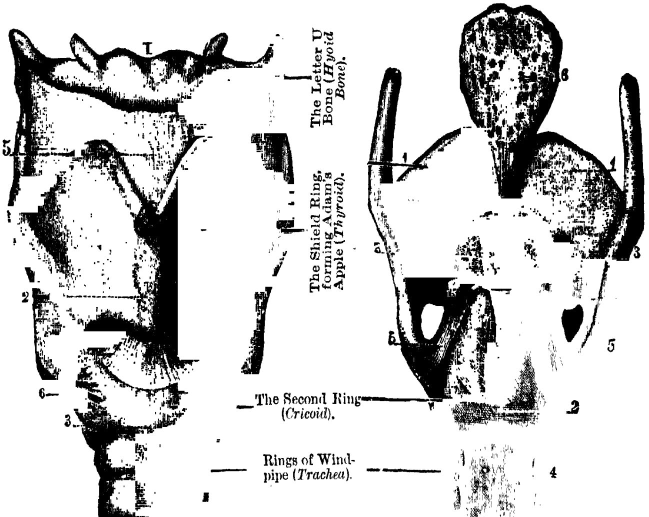


FIG. 94.—FRONT VIEW OF THE VOICE-BOX (*LARYNX*).

1, hyoid bone; 2, thyroid cartilage; 3, cricoid; 4, first cartilaginous ring of the trachea; 5, membrane; 6, ligaments.

FIG. 95.—BACK VIEW OF THE VOICE-BOX (*LARYNX*).

1, thyroid; 2, cricoid; 3, arytenoid cartilages; 4, upper ring of the trachea; 5, ligaments; 6, epiglottis.

will play next Saturday. It is a capital game, especially if the leader is a brave one and does not mind a little danger or a few disagreeables.

It is this game that the two cartilages which may be called

The Pitcher (*Arytenoid Cartilages*)

play with the second ring. They are capital players, and

they are none the worse for having a long name, for certainly, whatever can be said against them, it cannot be said that they do not play fair. They follow their leader, the second ring (*cricoid*), without pause or question. Whatever he does, they do. "They are something like good players," you will say; but while not wishing to lower your good opinion of them, I am bound to add that they exactly copy their friend the second ring (*cricoid*), because they are fastened to him and cannot very well help it.

These close friends of the second ring (*cricoid*), the pitcher cartilages (*arytenoid*), are a very curious shape. They resemble two sharp-pointed rocks shaped almost

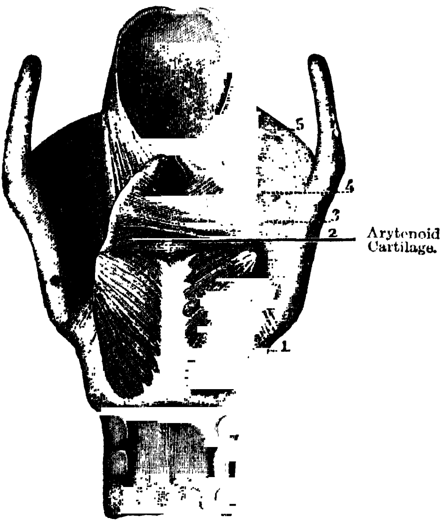


FIG. 96.—POSTERIOR MUSCLES OF LARYNX.

1, posterior crico-arytenoid; 2, arytenoid; 3, 4, oblique fibres passing round the sides of the arytenoid cartilages to form 5, the muscles which connect these cartilages to the epiglottis.

like the great pyramids. In this picture you will see their form.

You must not imagine that because they follow the movements of the second ring muscle (*cricoid*) that therefore the pitcher (*arytenoid*) cartilages have no dealings with the first ring—the shield ring (*thyroid*).

On the contrary, they are firmly attached to it by two bands of elastic fibres, and these fibres are called

The Vocal Cords.

Now the duty of the pitcher cartilages, with their muscles, is to move the vocal cords nearer to or further from each other. When they are near together, the air, in passing through them, makes a noise, and we speak. When they are further off from each other, no sound issues, but we can take in more air into the lungs. As the air comes out of the windpipe it hits these cords, which we can use or not use according to our wish.

I do not suppose that any of you have been in the desert, but it will interest you to learn that there is no noise in those great sandy plains. All around they stretch ; the strong sun and the blue sky above ; yellow, red, grey fine sand on every side ; and no sound amid it all. I have stood in the desert where Mahomet learned his lessons. I have seen the plains to which Moses fled. Both are silent. "Why is this?" you will ask. "Is there no wind there?" Yes, plenty strong fresh winds, and hot, dry, exhausting breezes, but there is nothing for them to strike against, and so they sweep over the flat land and cause no noise.

Sound is the result of the air striking certain obstructions which stand in its way.

The air leaves the lungs and comes up the windpipe. If we want to speak we bid certain obedient muscles to stretch the cords. When they are tight, the air hits them and causes them to vibrate, and sound is the result. If we do not want to speak the vocal cords hang loosely, and the air passes easily in between them and out without causing a sound.

"You must not even try to speak in public for three months at least ; your vocal cords must have rest," was the verdict given the other day to a public speaker. It

did seem a pity, for this man seldom spoke out publicly without doing good, but there was no cure for it. He had "lost his voice" because, as he shouted out of doors to great crowds who were too poor to hire halls, he had stretched his vocal cords too much, and now they refused to obey. If we could have seen them they would have looked like a bit of elastic out of which all the "stretch" had gone.

In more than one way do the vocal cords move, as you will see by this picture. The first, A, shows how the voice-box (*larynx*) would look during the singing of a high note. The second, B, tells its appearance while quick breathing only is going on. The third, C, indicates how it would look while a very deep breath was being taken.

So much for the voice-box (*larynx*), but that is not the only part of the body that is concerned in producing speech. The brain also has to work.

To give the command, "Pull this muscle, shorten that one, twist the other," is not the work of the voice-box. The orders must come from the brain; it is the voice-box's (*larynx*) duty to obey.

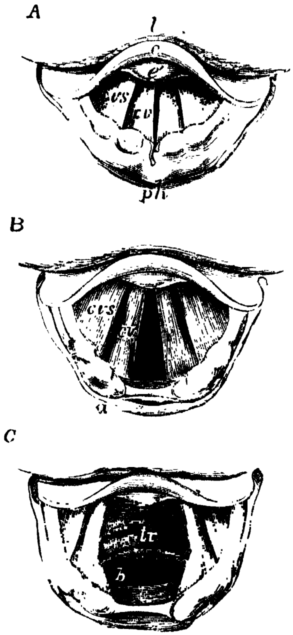


FIG. 97

l, base of the tongue; *e*, upper free part of the epiglottis; *e'*, lower portion of the epiglottis; *ph*, front wall of the pharynx behind the larynx; *a*, tip of the arytenoid cartilage; *cv*, vocal cords; *cvs*, superior or false vocal cords, which do not aid in the production of the voice; *tr*, front wall of the trachea; *b*, commencement of the two bronchi.

Not very long ago all kind hearts were saddened because a terrible railway accident had killed some and

injured many other people. Suddenly, without warning, the travellers were dashed over a precipice, and awoke from their amazement either to find themselves in terrible pain or half buried in the *débris*. One man arose from amid the wrecked carriages and smashed luggage with unbroken bones and a whole skin, but speechless. The doctors examined him and suggested remedies, but all unavailingly. His voice-box (*larynx*) was perfect, his throat uninjured.

"Why then could he not speak?"

He had received a blow in front and above the left ear, just where the governing powers of the voice-box (*larynx*) live; they were injured, and so it could not work.

I wonder if he was a nice man, this unfortunate creature who was made speechless in the accident, if he had used his powers of utterance

"To guide, to comfort, or command,"

or if he had talked only to get things for himself and his own pleasure?

The gift of talking is a great one; and no one can have been alive even for ten years without having seen the good influence of kind brave words, or the bad influence of lying mean ones. It is well to cultivate a gentle voice. Why should words be said so loudly? A great many things in life would be easier if people spoke more gently and in low tones.

"A woman's greatest charm is a low sweet voice," has been said by one of the world's great writers. A sweet voice is not only charming, it is also very influential. Gentle words, spoken gently, will calm the angry, soothe the sick, and give courage to the frightened child. It often puzzles me why mothers do not teach their children to modulate their voices. Many a weary hour is spent in trying to make a piano utter sweet sounds, but few minutes are given to train the box of the voice to speak music—the most perfect musical instrument which has ever been made.

Just at the very moment that a mouthful is being swallowed, it is not possible to speak. That is partly because the oval door (*epiglottis*) has closed and kept the wind from coming out, and partly because the muscles of the voice-box are disarranged by the extra room that the food wants, and so are not in working order, and this is one of the reasons why baby leaves off crying when he gets the bottle.

CHAPTER LIV

THE JOURNEY OF A SOUND

THE OUTER EAR—THE MIDDLE EAR

To-day you shall hear something about the ear. You all know how ears look outside, but you do not know how they appear inside. Some ears are big, and stick out from the head; some are small, and lie close to the skull.

"She has an ear like a shell," some one once said of a pretty little girl, to which an old country lady added—

"May she hear God's whispers then," referring I suppose to the old idea that shells whisper of the sea which is their home.

Every one has two ears, and each of the two is divided into three parts—

The Outer Ear, The Middle Ear, The Inner Ear.

We will talk of each separately, though it will perhaps make it easier if I show you the picture of all three ears at once (Fig. 98).

The Outer Ear

is not only the part that you all see, but also the little passage that seems to lead into the head, and down

which the water sometimes goes when you dip your heads in the bath. The use of that part of the outer ear which you see is not quite clear. It is called

The Wing (*pinna*).

If it were larger it would be useful to collect the sounds and to carry them towards those wonderful arrangements

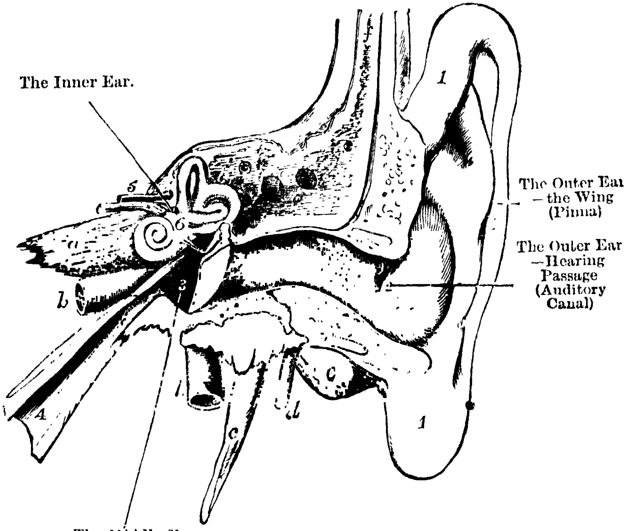


FIG. 98.—DIAGRAMMATIC FRONT VIEW OF THE LEFT EAR.

1, the pinna and lobe; 2 to 2′, the auditory canal; 2′, the tympanic membrane; 3, the cavity of the middle ear—above 3 is the chain of small bones; 4, Eustachian tube; 5, the facial and auditory nerves; 6, placed on the vestibule of the labyrinth., above the fenestra ovalis; *a*, *c*, *e* and *f*, portions of the temporal bone; *b*, internal carotid artery; *d*, branch of the facial nerve.

that enable people to hear, and about which you are going to learn. You have all seen horses and dogs and donkeys prick up their ears. That is, they turn them

towards the direction whence the sound proceeds in order to collect the sound waves and direct them down the passage, but we cannot prick up our ears. So the wing (*pinna*) is no good for that.

It may be that they are only for ornament, or perhaps man used to have the power of moving his ears, only that now he no longer lives by the aid of his acute hearing, the muscles which are there for that purpose have fallen into the weakness of disuse.

But besides the wing (*pinna*) the outer ear consists, as you know, of the passage leading inwards. It is about an inch and a half long, and you can get your little finger down it until it reaches some yellow wax. It is called

The Hearing Passage (*Auditory Canal*).

This passage is lined with some fine hairs that push anything out that may get in, and that gradually send the wax out also. This wax is made by some tiny glands situated about three-quarters of an inch down the passage. They secrete very slowly, and the wax is evidently meant to take care of what is beyond it.

Shall we imagine that we are going to send a sound on its journey from the air to your brain? Shall the sound be a note of music or a word? If you decide it shall be a note of music, you must ask your teacher to sing it to you. If you wish the sound to be a word, let us take some big word like Duty—Patriotism—Love—Mother—God—so that when it reaches our brains it may give them a good thought also.

Shall we take the word Duty? Your teacher says it. As it leaves the mouth the air vibrates.

Have you ever thrown a stone into a pond? Once, when I was a little girl, I was idly throwing stones into the duck-pond in our garden. Splash! went the stone.

"Quack! quack!" said the ducks, wriggling off as quickly as they could; and when they were gone, and it was no longer any fun to tease them, I still went on throwing the stones. Each one as it splashed made a

ring in the water as it fell, and the ring widened and widened.

"It will never stop," said nurse, who, as usual, came to see if I was spoiling my frock. "It is like a word. Once said, it goes on and on through the air."

I did not understand her, and I am not sure she understood herself, but what she meant was that the word struck the air and made waves much like the stone had made them in the water. This is true. When your teacher says "Duty," the sound makes waves in the air, and these little waves enter into the wing (*pinna*) and travel down the passage, past the little hairs that turn their points all outwards, through the yellow wax, till they arrive at a sort of wall which reaches right across the passage. This wall is the end of the outer ear. It is called

The Drum of the Ear (*Tympanic Membrane*).

It is made of a sort of thin skin, and is stretched very tightly across the passage from one side to the other, much like the top of a drum is stretched across from one of its sides to the other.

When we were in Japan I went to see a school where blind and deaf and dumb children were all brought up together. The blind played music, and made much noise, but the deaf went on with their queer painting quite undisturbed. The air waves were there hitting their ear drums, but the machinery inside was broken, and the brain got no news of it.

One side of this little wall or drum of the ear ends the outer ear. The other side is the beginning of

The Middle Ear.

"'Tis my wall, I tell you," said one countryman.

"It is not. I affirm it is mine," replied his neighbour.

"There is sure proof that it is my wall," argued the first man, "for see it ends my field."

"I have as good a proof," answered the second; "the wall must be mine, for it begins my garden."

So they quarrelled, these two silly people, who as

neighbours ought to have loved one another; and no one can tell how they settled the dispute! It is a good thing that the outer ear and the middle ear do not quarrel in the same way about their wall, for that is what the drum of the ear (*tympanic membrane*) is to them. 'Tis a sort of wall ending up the larger field of the outer ear, and beginning the smaller garden of the middle ear. Like the countrymen's wall, it is used by both of them.

"Rat-a-tat-tat-tat" beat the air waves that began when the word "duty" was said against the drum of the ear, and their beats give rise to other beats or waves on the other side of the drum, a small cave of a curious shape. The middle ear you will find it called in the picture. From it leads another passage called by a long name—

The Ear-Pipe (*Eustachian Tube*).

I once knew a lady who had very delicate ears, and once when we were travelling together among the high mountains she got a bad pain in her ear. She tried to enjoy looking at the beautiful scenery and large snow-fields, but the pain soon got so bad that she had to give it up and go to bed in the quaint little wooden hut in which we were staying. After a few days of great suffering she said that she felt some nasty fluid running down into her throat, and then the doctor, for whom we had sent from the large town in the valley, said that she would soon get better, for that she had had an abscess in her middle ear, which was now broken, and that all the nasty matter was running away down the ear-pipe (*eustachian tube*) into the stomach.

You will not, I hope, have forgotten that we spoke of it in Chapter XXVIII. when we learnt about the throat chamber (*pharynx*) and the doors leading into it.

"How does the air get to the inside of the drum of the ear?" I asked a girl to whom I had been telling some of these marvels.

"By the other ear," she quickly answered.

Then she was laughed at, and you will think she deserved it, will you not?

CHAPTER LV

THE JOURNEY OF A SOUND

THE HAMMER—THE ANVIL—THE STIRRUP

"RAT-A-TAT-TAT-TAT" play the air waves against the drum of the ear (*tympanic membrane*). They give rise, as I told you, to other waves in the middle ear. I can't explain to you just how this happens, because it is a very difficult subject to understand, but in carrying these waves across the middle ear there are three tiny little bones which help. They are not nearly so big as they look in the pictures. They are called

The Hammer (*Malleus*).
The Anvil (*Incus*).
The Stirrup (*Stapes*).

The hammer (*malleus*) leans close and tight against the drum skin, and when it shakes the hammer shakes too.

The anvil (*incus*) leans close and tight against the hammer, and when it shakes the anvil shakes too.

The stirrup (*stapes*) is fastened on to the anvil, and when it shakes the stirrup shakes too.

Here is a picture of them—

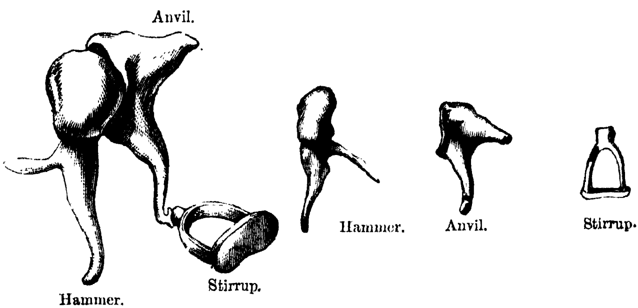


FIG. 99.—THE EAR BONES.
The Hammer (*malleus*). The Anvil (*incus*). The Stirrup (*stapes*).

by which you will see their shapes. Turn now to diagram on page 214, and you will see exactly where they are placed.

The hammer is tight against the drum of the ear. The anvil is tight against it; tight to it is the stirrup, and the stirrup itself is tight against a queerly shaped bone. About this odd-shaped bone I must now tell you. It is very difficult, but you must make a strong effort, and the blood will obey your will and fly to your brain to feed it and help you to understand what is coming. There is a picture on page 222 of

The Inner Ear (*Osseous Labyrinth*).

It has three parts. The central part looks like nothing in particular, but the right-hand part of it is something like a shell, and the other part of it is something like a bow of ribbon in three loops (Fig. 100).

The part that looks like a shell is called

The Shell Tube (*Cochlea*).

If we were to cut it open and apply a very strong microscope and much patience, we should find a great deal in it to astonish and delight us.

The part that looks like loops of ribbon may be called

The Ribbon Loops (*The Semicircular Canals*).

If you look you will see that though there are three loops, yet they only have five instead of six openings, because two of them join together before they run into the middle part. This middle part is called

The Entrance Room (*Vestibule*).

I shall have something to say about each part separately, but I must also tell you of a wonderful arrangement which concerns them all. These three parts are all full of a sort of water, and the name of the fluid is

Clear Water (*Perilymph*).

All is very tiny, but floating in this clear water and

exactly shaped to fit the shell (*cochlea*), the ribbon loops (*semicircular canals*), and the entrance room (*vestibule*), is a little bag. It has a long name, but you may call it if you like

The Skin Maze (*Membranous Labyrinth*).

It is such a dainty bag, made of skin, a very fine skin, and it is full of water. "Full," I say, and so it is full; but altogether it is only one tiny drop.

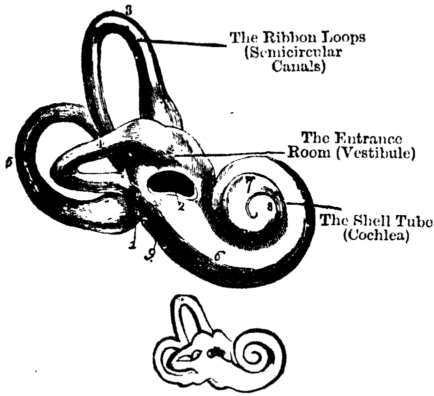


FIG. 100.—THE RIGHT BONY LABYRINTH.

1. Vestibule; 2. fenestra ovalis; 3, 4, and 5, semicircular canals; 6, 7, and 8, the cochlea; 9. fenestra rotunda. The smaller figure below shows the natural size.

"Duty," said the teacher, and we have followed the air waves made by that word into the wing (*pinna*), down the little passage (*auditory canal*), past the tiny waving hairs, the rich yellow ear wax, through the drum into the cavity.

We have seen the hammer, the anvil, and the stirrup each shake as the waves touch them. And we left, as it were, the stirrup still vibrating. We must leave it yet a little longer, for though you have learnt to-day some-

thing about the parts of the third or inner ear, you have not learnt what they have to do with the sound waves.

Many people box children's ears. It is very dangerous. Mrs. Buckton tells of a poor boy who died because he was stupid, and his father thought to make him "mind his books" more by blows that would "wake him up." Sometimes also the ear is injured by forcing the wax down in the desire to clean the ear.

"It pains so," whimpered a poor little mite one hot day, as I was visiting some of my friends in a close alley in Whitechapel, and as she softly cried, holding her hand to her ear, her kindly but ignorant mother said—

"Yes, 'tis the wax she's got in her ear," and taking the child on her lap, she screwed up the corner of the towel and tried to probe it down the ear passage (*auditory canal*). Ah, now you see how foolish it was. She thereby only hardened the wax, and pressed it still more tightly against the little skin drum-head that already ached from cold or pressure.

Nature has so arranged that if left alone the ear wax dies and comes out in dust or flakes. Anyhow, to harden it by pushing it down is an unwise plan.

CHAPTER LVI

THE JOURNEY OF A SOUND

THE SHELL TUBE—THE EAR STONES

"Duty," says the teacher, and the sound waves travel by the path we know until they reach the stirrup which we left vibrating.

What we may call the foot of the stirrup is pressed tight against the inner ear. Fig. 101 is a picture of it.

You will see that the stirrup is pressed not against

the shell, nor yet against the ribbon loops, but against the part that lies between both, and is called

The Entrance Room (*Vestibule*).

Now, the reason for this is very wonderful. All sounds, as you know, travel into the ear by the same pathways.

"Rat-a-tat-tat" sounds the stirrup against the little

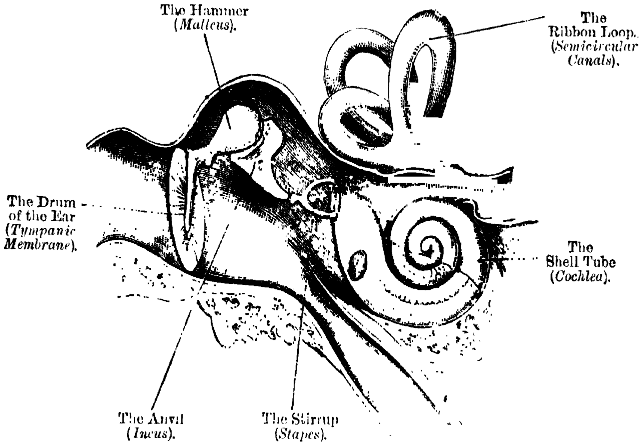


FIG. 101.—INTERNAL EAR GREATLY ENLARGED.

opening, and into the entrance room (*vestibule*) go the sound waves. Do they stay there? No. They go on into the shell tube.

What do they find inside the shell tube? We will follow them and see.

Shell Tube (*Cochlea*).

Here is a picture of how its inside would look, but the picture does not show one-hundredth part of all its wonders.

The shell, as you see, twines round and round, and

those little curls are made of fine hard but very delicate bone. Inside them is the bag of which you have heard. I told you it was a dainty bag, and so it is; but I did not tell you half its wonders. First, it is very tiny. When I speak of a bag I sometimes fear you will think I mean a bag as large as a potato sack or a trousers pocket. This bag is very small, and yet on its skin are rows of little hammers.

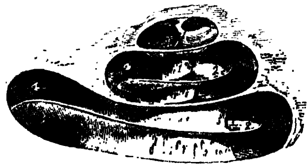


FIG. 102.—THE VIEW OF THE INSIDE OF THE SHELL-TUBE (OSSEOUS COCHLEA).

Have you ever seen the inside of a piano? If you have, you will have seen rows of little hammers. You put your finger on one of the white notes or keys and strike it. Up jumps a little hammer, and as you move your finger, down it falls and strikes a wire below it. This makes the sound. But the hammers in the piano

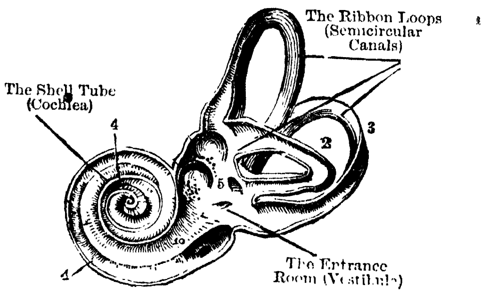


FIG. 103.—THE INSIDE OF THE INNER EAR, LEFT LABYRINTH.
1, 2 and 3, semicircular canals; 4, cochlea; 5, vestibule.

are big—each one is an inch or an inch and a half in size—but the rows of hammers on the skin bag (*membranous labyrinth*) inside the tiny shell of the inner ear are so small that you could not possibly see them without a very strong and delicate microscope.

The picture looks complicated enough, does not it? That is of the long inner ear, but the skin bag which is inside it is far more complicated still, and it is quite useless to attempt to explain it to you. Some parts of it, namely, the parts which are enclosed in the ribbon loops (*semicircular canals*), probably have nothing to do with hearing at all, but are there for another purpose. The part that has to do with hearing is inside the shell tube (*cochlea*), and it is this part which carries the little hammers.

Some of the wise men who understand about the ear do not think that it is the hammers that carry the sound, but all are agreed that it is the shaking of the water against something that sets the nerves in motion; but whether that "something" is these little hammers or some tiny hard hairs that are placed around them, no one has yet been able to discover.

"Duty," says the teacher, and now we will follow the word.

Into the outside ear or wing (*pinna*).
Down the hearing passage (*auditory canal*).
Past the little hairs (*cilia*).
Through the ear wax (*cerumen*).
To the drum of the ear (*tympanic membrane*).
The hammer (*malleus*) begins to tremble.
The anvil (*incus*) begins to tremble.
The stirrup (*stapes*) begins to tremble.
Their trembles vibrate into the entrance room (*vestibule*) and from thence
Enter the shell tube (*cochlea*) or the ribbon loops (*semicircular canals*).
Shake the clear water (*perilymph*).
The shaking of the clear water (*perilymph*)
Moves the skin bag (*membranous labyrinth*),
And shakes the water within it (*endo lymph*).
This moves either the hammers or the hairs, and these
Touch the nerve ends and
Convey the news of sound to the brain by

The Hearing Nerve (*Auditory Nerve*).

"She has no ear for music," a father once said sadly about his child.

"Well, well! don't trouble about that—she will cultivate one," said his friend, wishing to cheer him.

"She cannot do it if her ear has not got the necessary appliances," said a doctor who was in the room.

"Tut, tut!" said the second friend; "she can if she tries. I have known several cases when people did not seem to have any idea of music to begin with, and then played the piano well in later life."

"But she can't," urged the doctor, "she can't create in her ear that which nature has left out."

Both were right to a certain extent.

Perhaps some people have either more little hammers or more little hairs than others, and those people are the musical ones. They can hear the tiniest difference in the sound waves which others cannot distinguish. Perhaps there are other reasons.

Some animals hear far better than human beings. A horse or a dog can hear notes that we cannot; but, on the other hand, there can be no doubt that trying to hear and distinguish sounds, which is done by the cultivation of music, helps these little organs to develop and become more alive, just in the same way as working at the forge helps the blacksmith's muscles to grow and become strong. Listening is ear-growing.

There is an extraordinary difference between wave sounds.

If I struck the lowest note which the human ear can hear, it would travel into your ear in about the fourth of a second, and if we could measure it as we could measure the wave made by the stone thrown into the pond, it would be about twenty yards long. But if I struck the highest note that the human ear can hear, it would travel to your ear so fast that 74,000 of them would only take one second to reach it, and if we could measure it, it would be less than a quarter of an inch long.

Is there not a great difference between the two? *Lowest*, twenty yards long, the fourth of a second to travel.

Highest, less than one-fourth of an inch, and 74,000 in a second.

Can you not now imagine how delicate and fine must be the instrument which can measure all these sounds, and how important it is not to injure it.

CHAPTER LVII

THE JOURNEY OF THE LIGHT

THE EYE AND ITS COVERS

To-day we are going to talk about the eye, that wonderful organ which enables us to know so much that ears cannot hear or fingers touch.

Just pause a moment or two, and try and think what you take in by your eyes which no other sense helps you to understand. How sad it is when those beautiful organs get injured, and the "soul windows" are for ever curtained. Blind people lose a great deal.

"Which would you rather be— blind or deaf?" an old and gentle lady was once asked.

"Deaf," she immediately replied, without waiting a moment to think, "because I could then see when people wanted helping. If I were blind I should have to wait until they told me."

Did it not show a sweet and sympathetic nature that her first thought was not for herself or what she would lose, but which sense enabled her to be of most use to other people?

The eye is a very delicate instrument, easily injured, difficult to repair, and not at all simple to understand. However, once more you must try and "put on your thinking-caps," as one of my little pupils used to say when anything very difficult had to be learnt.

We will first speak of those parts which have as their object the protection of the eye. There are three of them—

The Eye Brows, The Eye Lashes, The Eye Lids.

The **eyebrows** are little rows of hairs just at the bottom of the forehead, one over each eye. If you ask—

"What is their use?" I should have to answer—
"A twofold use."

First, eyebrows add to the beauty of the face. Did you ever see any one without eyebrows, or with such light-coloured ones that they hardly showed? If you have, you will know how much that row of little hairs over each eye adds to the appearance of the face.

Secondly, eyebrows are useful to prevent the perspiration rolling down the forehead into the eyes. Some people perspire very much. If this profuse perspiration ran into the eye it would be injurious or troublesome, so nature has provided little brushes that catch it, and prevent it going further than it should do.

The **eyelashes** are the hairs that grow on the edge of the eyelids. They, like the eyebrows, have a twofold use—they serve to make the eyes more beautiful, and they warn the eye of the approach of dust and flies and little bits of leaves and things that might otherwise be driven into it by the wind.

Have you ever seen a fly flying straight towards your eye? Quick as thought you close it, though sometimes not quickly enough; but in any case the eyelashes close before the eyelids, and keep off some of the things that might otherwise go into and injure the eye.

I remember once, when we were driving in a very lonely part of the country, coming across a young man who had got off his bicycle, and was sitting, evidently in great pain, on the bank. We went to his assistance, and found that he had got something in his eye.

"Strange, too," he said, when we had got it out, and he was thanking us, "for when I face a wind I nearly always ride with my eyes half shut, and look through my lashes." He had learnt by experience the use of his eyelashes.

But useful as eyebrows and eyelashes are, it is the **eyelids** that are the real protection of the eye. There are two, the upper and lower lid, and they close voluntarily by the action of a delicate but strong muscle, which is formed like a ring round the eye. This muscle is called

The Small Circle Muscle (*Orbicularis*).

The eyelids are lined by one of those wonderful skins about which you have often heard in this book, and which are called wet skins, or mucous membranes. This wet skin has a special name, or it may be called

The Joining Wet Skin (*Conjunctiva*).

It lines the eyelids, and then turns back again and goes over the eyeball itself. Thus the eyelid is lined and the eyeball covered with the same sort of skin.

The use of the eyebrow and the eyelashes and the eyelids and the joining wet skin (*conjunctiva*) is to protect the eyeball.

Why does it need so much protection?

Because it is so delicate; and it is not only delicate, it is very complicated and difficult to understand.

The Eyeball

is round, as its name shows. All that is visible, both the white and the coloured part, as well as a great deal more about which you are going to learn, is included when we speak of the eyeball. It lies in a socket. Did you ever see an orange sitting in the middle of a soft downy pillow? That is how the eyeball sits in its socket. The eyeball is firm and hard; the socket is soft, and made of fat. If a child sat on the orange it would sink further into the soft cushion, but if it had been placed on a hard chair and some one had sat on it, it would have been crushed quite flat.

"It did not hurt much, dear, did it?" said an anxious mother to her boy of eight, whose brother had just thrown a ball which had hit his eye.

"No, mother, not much," he said, "my eye seemed to go in."

What made the little chap say so I can't think, for I don't suppose he had ever heard of the eyeball lying in its cushion of fat, but his words expressed something very near the fact. As it lies comfortably on its fat cushion, the eyeball must be kept clean. How this is done must be told in the next chapter.

CHAPTER LVIII

THE EYE—WHAT WASHES AND MOVES IT

We left the eyeball comfortably lying on its cushion of fat waiting to be washed. This is done by water which is made (*secreted*) by

The Tear Gland (*Lachrymal Gland*).

The glands, you know, draw out from the blood certain materials, and make them up into something else, and this something they put aside until it is wanted.

The tear gland is one of these secreting glands. It prepares tears, and stores them for the use of the eye.

"Are we then always crying?" asked the happiest of happy little girls. "I did not know that. I thought we only cried sometimes when we could not manage things."

"Yes," said the teacher, "the tear gland is always at work making tears." These tears are the water that keeps the eyeball clean.

The tear gland (*lachrymal gland*) is about the size of a small almond, and is placed by the eyeball on that side of it which is furthest from the nose. It makes a tear—or rather a bit of one—which runs down over and across the eye, washes it, and escapes into the opposite corner of the eye. From there it is taken by little pipes called

The Tear Canals (*Lachrymal*)

into another and a larger pipe (*lachrymal duct*), and by that into the nose.

Sometimes when we are sad this tearful gland works harder, and makes so many tears that the tearful canal (*lachrymal*) is not large enough to carry them all away,

and then they run down over the cheeks. Here is a picture which will help you to understand what has been said.

The Rhine is a beautiful river. It flows through steep rocks and finely shaped mountains. There are many vessels on it—boats that carry the village produce to the towns, and also steamships that take people up

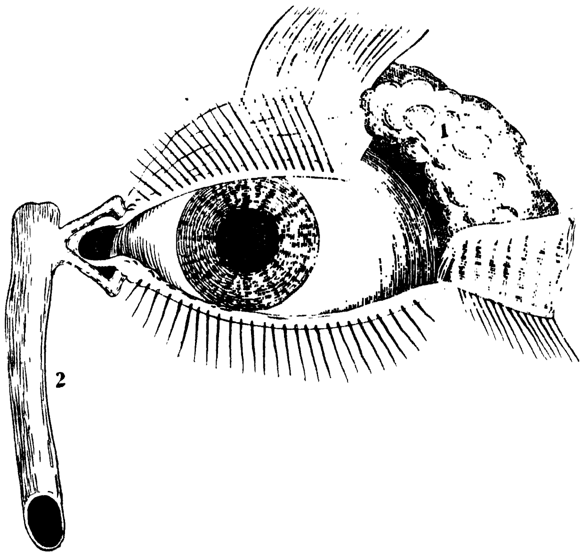


FIG. 104.—THE TEAR GLANDS.

1, lachrymal gland; 2, nasal duct; 3, the muscle which raises the upper lid.

and down the Rhine, and show them the beauties of Germany.

One day when on one of these river steamers a bit of coal-dust from the funnel got into the eye of an old lady. Poor thing, she suffered great pain, for she could not get it out.

" Blow your nose, while keeping your eye open," said

one; and that was good advice, and you will presently see why.

"Let me try," said another; but the shaking of the boat, and the old lady's fright, prevented any one really easing her. The next time the boat stopped at a town she had to get out and go and see a doctor, who explained to her in German that she ought to be very grateful that the "foreign body," as he called it, had given her so much pain, for

"If it had not done so," he said, "you would not have been so anxious to evict it, and then it might have done more serious mischief."

Now you know why the old lady was advised to blow her nose and keep her eye open when she had a piece of dust in her eye, so as to help it out by the tear canals.

But it is not enough that the eyeball should rest on a soft cushion and be washed. It must move. To enable it to do this there are no less than six muscles.

Four Straight Muscles (*Recti*).
Two Slanting Muscles (*Oblique*).

These six muscles allow the eyeball to move in the many ways that you know it can move.

They are voluntary muscles, and work in obedience to our will. There is a picture on p. 232 that shows how they are placed.

"Well, I hope never to see such a sight again. It was shocking."

"Yes, it was shocking. I agree with you," said the village doctor, who had come up unobserved by the speakers. "But I can't agree with you in hoping never to see it again, for if I can help a poor sufferer, I shall wish to be there."

"It is very good of you, I am sure, sir," said another woman; and then she, having an inquiring mind, asked—

"What made him roll his eyes so, sir."

"He had a fit, poor fellow," said the doctor, "and lost the control of the muscles of his eyes, and so they

each pulled a different way. You can imagine how a cart would go if it were yoked to six horses who each pulled a different way."

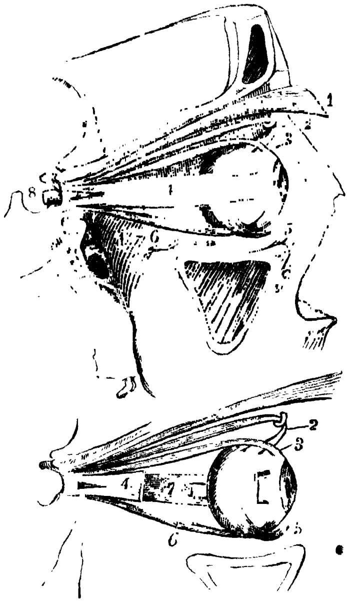


FIG. 105.—THE MUSCLES OF THE RIGHT ORBIT.

3, 4, 6, and 7 show the straight muscles; 2 and 5 show the slanting muscles; c, sphenoid bone; 1, muscle which raises the upper lid; 2, pulley and tendon of the superior oblique; 3, tendon of the superior rectus; 4, external rectus partly removed in Fig. 107; 5, inferior oblique muscle; 6, inferior rectus; 7, internal rectus; 8, optic nerve.

You see the reason why the muscles did not work together properly was that Father Brain was hurt and had to drop the reins of this team of six horses which he generally manages quite easily.

CHAPTER LIX

THE EYE AND ITS COATS

WE have seen how the eye was

1. Protected by its eyelids.
2. Washed by its tear glands.
3. Rested in its socket.
4. Moved by its muscles.

To-day we must consider its clothing. Like so many of the body's organs, it has three coats, but, unlike the other parts about which this little pink book tells, each coat is divided into several others. This will make it more difficult for you to learn, but the beauty and interest of these coats will, I hope, compensate for the extra hardness of the lesson.

The names of the three coats are—

The Outer Coat, which is divided into—

The Hard Coat (*Sclerotic Coat*).
The Horny Coat (*the Cornea*).

The Middle Coat, which consists of—

The Coloured Coat (*Choroid Coat*).
The Hairy Coat (*Ciliary Processes*).
The Curtain (*the Iris*),
In the middle of which is **The Round Hole** (*the Pupil*).

The Inner Court, which is—

The Network Coat (*the Retina*).

We will take the outer coat first, which, you know, is divided into two.

The Hard Coat (*sclerotic coat*) covers the back part of the eyeball. It is white and opaque.

The Horny Coat (*cornea*) covers the front part of the eyeball.

It will perhaps make it easier to you if I say that the hard coat is like a boy's jacket, which protects his back,

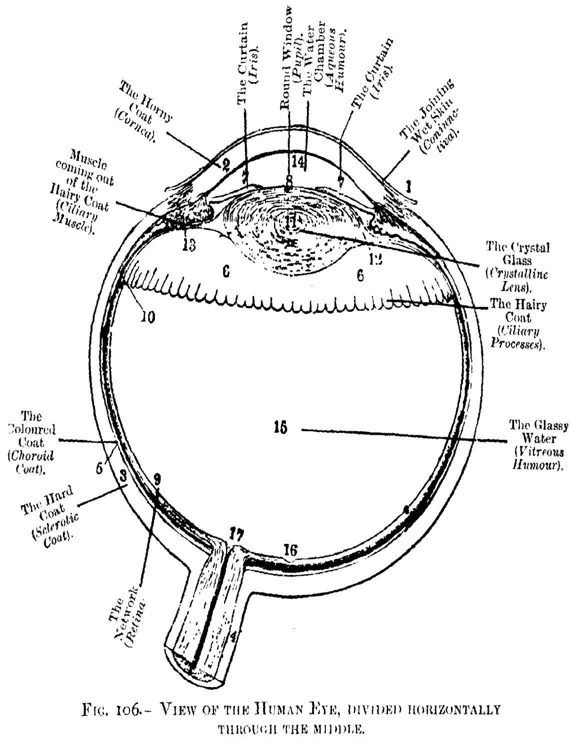


FIG. 106.—VIEW OF THE HUMAN EYE, DIVIDED HORIZONTALLY THROUGH THE MIDDLE.

1, conjunctiva; 2, cornea; 3, sclerotic; 4, sheath of the optic nerve; 5, choroid; 6, ciliary processes; 7, iris; 8, pupil; 9, retina; 10, anterior limit of the retina; 11, crystalline lens; 12, suspensory ligament; 13, ciliary muscle; 14, aqueous chamber; 15, vitreous chamber; 16, yellow spot; 17, blind spot.

and the horny coat is like a waistcoat, which protects his stomach, though unlike a boy's waistcoat the horny coat

(cornea) is transparent, as transparent as a watch-glass. There is a drawing on p. 234 which will help you to understand something about the eyeball.

You will see that right round the eyeball goes the outer coat, but at the back it is called the hard coat *(sclerotic coat)*; in the front it is called the horny coat *(cornea)*.

There are certain things you must know about these coats. They are both very hard indeed. They are stiff, firm wrappers, and do not easily give way. If you came to cut them, it would be like cutting leather. Some people rub their eyes much more roughly than others, and that is because in their eyes these coats are extra tough.

Now we must consider the middle coat, which you know is divided into four.

The coloured coat *(choroid coat)* also covers the back part of the eyeball. It lies immediately underneath the hard coat. It is full of blood-vessels, whose duty it is to form a warm bed around the retina, and to supply and take away blood from the whole eyeball.

As long as the middle coat is at the back of the eyeball, it is called the coloured coat *(choroid)*, but at the sides it is re-named. You may not be able to remember its long name, so you may call it

The Hairy Coat *(ciliary processes)*.

It does the work of a joiner—it joins together the back and the front of the middle coat, and makes folds hardly bigger than hairs, in which tiny nerves and muscles are covered up safely.

Two names already has this middle coat, and there are yet two more to learn about, for as soon as it gets exactly to the front of the ball it is called

The Curtain *(the iris)*.

Here the colour cells reside which determine what is commonly called the colour of the eyes.

"What lovely eyes she has! but I don't know what

colour to call them," said a young girl who was enthusiastic about her school friend.

"Umph!" growled her brother, a medical student, who hated to hear what he called "girls' gush." "Why not say at once that her colour cells are unequally distributed, and variable in size?"

"Really, George, you quite vex me," said his sister. "As if her lovely eyes depended on her cells! It is the soul in them that is beautiful."

"All right, dear," replied the aggravating boy, "but the colour is in the cells all the same."

And he was right, although tiresome. It does depend on the colour cells which are hidden away in the curtain (*iris*) whether eyes are brown or blue, grey, black, or green-hazel.

In the very middle of the curtain (*iris*) is

The Round Window (*the pupil*).

We must speak of both these together. They are like the boy's shirt-front and his stud-hole; but first, with the teacher's kind help, we will make an experiment.

Let one of the children sit down in front of the teacher, with his face towards the light. Now we want to observe the effect of light on the pupil of the eye, but you cannot all observe it at once, but two children at a time can come near enough to see the iris and the round window. What is the child's name who is sitting down? We will call him Tommy for short. "Now, Tommy, look at the window." "Please, teacher, I can't see anything because you have both your hands up close to my eyes, and it looks all dark." Now the teacher suddenly takes his hands away while Tommy is still trying to look at the window, and if you are sharp, you two boys or girls, you can see that for a moment the pupil of Tommy's eye is much larger than when you saw it first, but at once gets small again.

Now I will tell you why.

The title of this section is "The Journey of the Light." What is light?

You learnt that sound was caused by air waves. Light also is caused by ether waves.

It may be the middle of the day in India when the sun is the brightest, but the blind man sitting there under the palm tree cannot see the light because the delicate instrument that ought to enable him to catch the ether rays has got damaged.

Some of these light waves are much larger than others. Mauve rays are the smallest, while red waves are the largest.

These light waves approach the eye. They touch the joining wet skin (*conjunctiva*), but it can do nothing with them—no more than the skin of the hand or cheek can do. They touch the horny coat (*cornea*). It can do nothing with them, but as it is transparent it lets them through.

They touch the curtain (*iris*). It can do nothing for them, but in the very middle of its blue or brown self it has a little black hole (*the pupil*), and through it travels these light waves. The pupil looks black, but it really is no colour at all. It only looks dark as the opening to a tunnel appears black.

The curtain (*iris*) has some very curious muscles, which enable it to make its round window (*pupil*) large or small. On page 238 is a picture which will help you to understand this.

If many light waves strike the round window (*pupil*) it does not want them, and so the curtain (*iris*) uses its muscles, and the window (*pupil*) becomes very small, too small to admit many. If there are but few light waves to strike the pupil, as was the case when the boy was in the half light, the machinery inside wants them all to come in; then the careful iris will use one set of its muscles, and the pupil will become larger and ready to take them in.

"Edmund, don't read by the firelight, dear, it is the worst sort of light for your eyes."

These words were spoken by a lady to her only boy, who, lying on a hearthrug, was engrossed in a book.

"Why, mother, what harm can it do me?" he answered.

"It overworks your eye muscles," she said. "As the fire jumps up and flickers down your pupil has to alter its size, and that tires the iris muscles."

"It doesn't feel tired, dear," he said, "but I won't do it as it vexes you."

A nice boy that.

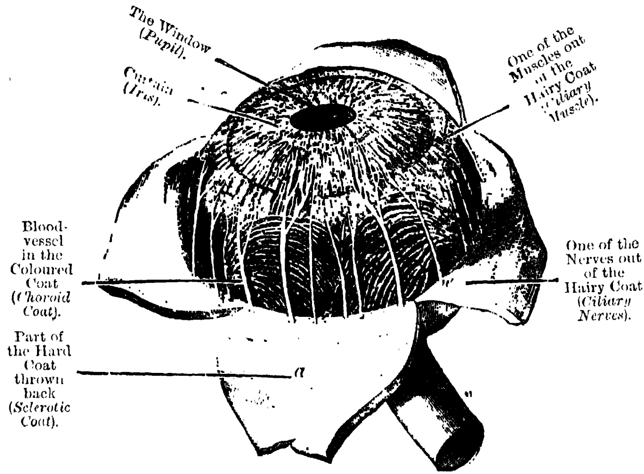


FIG. 107.—THE CHOROID AND IRIS, EXPOSED BY THE REMOVAL OF THE SCLEROTIC AND CORNEA.

"No, thank you, ma'am, I would rather not be her maid," a young servant said. She was very ignorant, and had been sent to see a lady who it was hoped would take her and teach her good household ways.

"Why not? Do you not think you can trust her as a mistress?" the girl was asked.

"No, ma'am, I think she is mad," was the answer.

"Mad! what has given you the idea?"

"The black spots in her eyes were an odd shape," the

girl said, "and I have always heard such people are mad."

"Foolish child," I said, for I knew that my friend had had to suffer an operation on the eye, by which the curtain (*iris*) had been cut. This had injured the delicate round muscle which opens or closes so as to admit the light waves through the round window (*pupil*) and prevented it acting as is usual in a circle. Thus

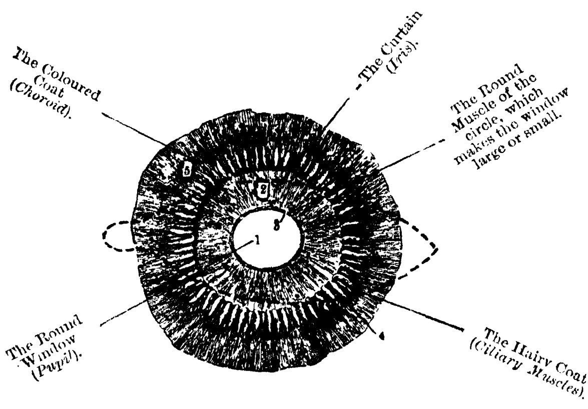


FIG. 108.—THE HAIRY COAT (*CILIARY PROCESSES*), AS SEEN FROM BEHIND. TWICE THE NATURAL SIZE.

1, pupil; 2, posterior surface of the iris; 3, circular muscle of the iris; 4, ciliary processes; 5, portion of the choroid.

the light waves had more space by which to enter and travel to the crystal glass, but the pupil was no longer round. I tried to explain something of this sort to the girl, but it was of no use. She would not go, preferring her ignorant opinion to "running the risk."

Before we quite leave the curtain (*iris*) and its round window (*pupil*) I must tell you that in front of it is a chamber called

The Water Chamber (*Aqueous Humour*).

It contains several drops of water which float about between the horny coat (*cornea*) and the curtain (*iris*). The light waves pass easily through this water chamber. The use is clear. It provides a space for the curtain (*iris*) to move in, much in the same way as the watch-glass contains an air space in which the hands of the watch can move.

About two of the eye coats you have now learned a little. The third we will study in the next chapter as we follow the light waves through the iris-curtained pupil.

The picture on page 239 will help you to see that the eyeball—in which is included the white as well as the coloured part—is round, and that the coats at the back join those in front in circles.

CHAPTER LX

THE EYE COATS—THE CRYSTAL GLASS

In the last chapter we left the light waves just as they were entering the round window (*pupil*) of the eye. Once inside, what do they find there? Before we follow them we must learn about **the third coat** of the eyeball, which was called—

The Network (*retina*).

It is very fine, and goes all round the back of the eyeball. Just as the coloured coat (*choroid*) lines the hard coat (*sclerotic*), so the network coat (*retina*) lines the coloured coat (*choroid*).

It is always easier to see things in little tables, so here is one which will show you the coats of—

The back of the eyeball.
The front of the eyeball.
The middle of the eyeball.

At the back of the eyeball are—

1. **The Hard Coat** (*sclerotic*).
2. **The Coloured Coat** (*choroid*).
3. **The Network Coat** (*retina*).

In the middle of the eyeball is—

4 and 5. **The Hairy Coat** (*ciliary process*).

At the front of the eyeball are—

6. **The Joining Wet Skin** (*conjunctiva*).
7. **The Horny Coat** (*cornea*).
8. **The Water Chamber** (*aqueous humour*).

9 and 10. { **The Curtain** (*iris*), in the centre of which is **The Round Window** (*pupil*).

11. **The Crystal Glass** (*crystalline lens*).
12. **The Glassy Water** (*vitreous humour*).

Here is a picture that will show the coats and other parts quite plainly, all twelve of them.

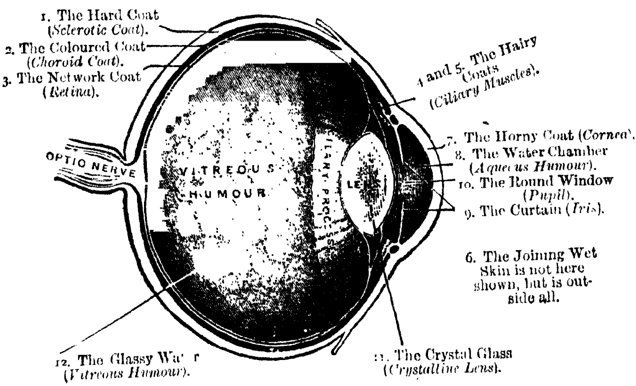


FIG. 109.—THE EYEBALL.

"We know something about the first ten," I seem to hear you say, "but what are the crystal glass and the glassy water? It sounds like a fairy tale."

Quite so. It does sound like a fairy tale, only it is, I think, more beautiful than any fairy tale, because all the wonders which those fascinating stories tell about are there, and at the same time it is "all quite true."

The Crystal Glass (*crystalline lens*),

as its name tells, is quite clear. It is something like both jelly and an onion. It is like the first in substance, but instead of being all run together like jelly it is placed in layers like an onion.

It is small, only about the third of an inch in size, and if we could see it it would look like a lovely crystal bead—an oval bead, not a round one. You will see it drawn on Fig. 109. It is held in its position, which, I hope you understand, is immediately behind the curtain (*iris*), with the round window (*pupil*), by some bands which you see in the picture. These bands are fastened, not to the crystal glass (*crystalline lens*) itself, but to a little tunic that it wears. It is a clear tunic, clear like the glass itself, and may be called

The Tunic (*Capsule*).

A most important duty has the crystal glass.

In the last chapter we left the light waves just coming through the round window (*pupil*). Directly they have passed through it they reach the crystal glass (*crystalline lens*). From wherever they come they go straight to it. From the clear sky, from the muddy pool, from the field on the right or the house on the left, the light waves rush—carrying the image of the thing from whence they come with them—and go without delay into the crystal glass.

"But does not it keep them?" No, no! it sends them on, and in so doing it turns them upside down.

Several times you have heard from me about the Japanese. They are a curious people and do lots of wonderful things in wonderful ways. But some of their ways are very queer. For instance, their books begin at what we call the end. They start reading from the

right of the lines instead of the left, and from the bottom of the page instead of the top. When they build a house they begin at the roof! and they bury their dead in a sitting up instead of a lying down position. They sew by putting the needle in and out away from the sewer instead of towards her as we do. The men and not the women do all the best needlework, and the horses stand in the stables with their heads looking out of the door and their tails at the manger! Is it not strange?

"This is topsy-turvy land," we used to say as we walked about the quaint streets, and saw all the dainty people with their funny ways, and this is what you would say if you could be a wee tiny creature, and live inside the crystal glass (*crystalline lens*), for its duty is to catch the light waves, and bring them to a point. In so doing they cross, and the image becomes topsy-turvy, and forms a little picture.

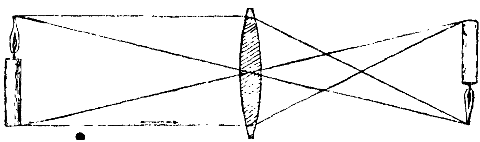


FIG. 110.—FIGURE SHOWING HOW THE IMAGE OF A CANDLE IS FORMED UPSIDE DOWN AFTER PASSING THROUGH THE CRYSTAL GLASS (*Crystalline Lens*).

You might think that this would cause us to see a candle or anything else upside down, but you know as well as I do that we don't, and if you think, you will understand that there is really no reason at all why we should. No one can see the back of his own eye when these topsy-turvy pictures are formed, and in fact it is not only with our eyes that we see but rather with our brains, the eyes being merely the half-way station, as it were, where the light waves from without are collected, and transformed into a shape in which they can be sent on ready for the brain to perceive.

"Are you near-sighted? I am," said one lady as she chatted over her tea at a working-party.

"No! I am long-sighted, and can enjoy views however distant," said the other.

What did they mean? They meant that in some people the eyeball was too long. In that case the little picture was formed too far in front of the wonderful network (*retina*), and it all got blurred. These people are called near-sighted. In other people the eyeball is too short to allow of the picture being properly formed, and so the retina cannot do all it should do—these people are called long-sighted.

Several times we have talked of the eyeball. You have heard of its coats—many in name and material—but you have not heard of it itself. Perhaps some one will say—

"I thought it was made up of all the coats."

So it is, and yet it is not. It is made up of the coats, and yet underneath them all is a centre—a kind of kernel. This is called

The Glassy Water (*Vitreous Humour*).

In Fig. 109 it is shown to you quite clearly. It is large; indeed, it is the largest of all the many parts of the eye. It is made of a kind of jelly, and is very soft. It is clear. The images of things pass through it quite easily.

The bottom of one thing must be on the top of another. This sounds very profound, but yet it is quite easy. Think a moment. You are standing. The bottom of your feet are resting on the top of the floor. You are in a house. The bottom of the house is resting on the top of the land. So it is true in the eye. The network (*retina*), which you will remember is the bottom coat of the eyeball, now becomes the top of this glassy water (*vitreous humour*). The retina is a very fine network, chiefly composed of tiny nerves. It has, as it were, hundreds of wee arms. These it puts round the jelly-like ball and waits for its work. What is its work? A very important one. It takes all the images

which the crystal glass (*crystalline lens*) brings to it, and tells the news to the brain much in the same way as during a war a telegraph clerk would receive news from any one who brought it to him, and telegraph it to headquarters. The road by which all the messages go is by

The Seeing Nerve (*Optic Nerve*).

The optic nerve is the eye's messenger. Quickly it travels to the brain, and, behold! we see.

Look at your slate pencils. Is there one thinner than the others? If so, it is about as thick as the seeing nerve.

All the tiny nerves of the network coat (*retina*) are gathered together till they make this seeing nerve, which then goes straight through the coloured coat (*choroid*) and hard coat (*sclerotic*), and out of the eyeball into the brain.

All the parts of the eye are important, each in their different degrees and positions, but two of the most important are the crystal glass (*crystalline lens*) and the network (*retina*).

If either of them are injured we cannot see, even if all the other parts are perfect and beautiful.

People are often colour-blind, and terrible railway accidents have taken place because the retina in the engine-driver's eyeballs is not quite perfect and able to distinguish between the different colours.

This is a long lesson, and I expect you will think that you have now learnt all there is to learn about the eye. So I must tell you that, long as these lessons are, you have only learnt a very little about it. I have not told you of the rods and cones, of the nine layers of the network coat (*retina*), of the yellow spot, of the black spot, nor of the wonders of the muscles and pulleys that work and move the eye or alter the shape of the crystal glass (*crystalline lens*). All this I have not explained because it is too difficult for you to understand. When you get older and your brains stronger, you can get another book and learn about it. I can, though, tell you that all is very interesting and very beautiful.

"Try a topsy," said a boy of fourteen to his grandfather.

"A what, my dear?" asked the old gentleman.

"A topsy, grandad. It is quite easy. You bend forward and look at the view through your legs, or if you are a girl—which you aren't—you put your head down near to the ground and screw your body round till you get your eyes bottom upwards. Do try it?"

"I am afraid I can't manage it," replied the aged man. "But why do you like it?"

"It makes the view look so much better, and has something to do with what's inside your eye," was the unscientific reply.

Could you tell him more about the cause? Anyhow you will probably take his advice and "try a topsy" before you are "too old to manage it." As you do you can wonder whether the extra beauty that you will see in the colours of the landscape is not caused because that part of the *retina* that is usually used to seeing the land is now asked to report news about sky colours, while those messengers which have told the brain so often that the sky is blue are now working away to carry news about the purples and russets and greens and greys which travel with the rays from the landscape, and as they are not tired or worn out they are doing it with more than usual clearness or vigour.

SUMMARIES

CHAPTER I

THE HUMAN BODY	1. Requires food.	2. Throws off waste.
	3. Requires to be kept clean.	4. Is preserved by use.
	5. Each part depends on the others.	

1. The human body requires three sorts of food—
   A. Strength-giving or carbonaceous food.
   B. Flesh-repairing or nitrogenous food.
   C. Health-preserving or mineral food.

2. The human body throws off waste—
   By the breath and perspiration, and by the aid of kidneys and liver.

3. The human body requires to be kept clean—
   By the aid of air and water.

4. The human body is preserved by use—
   Disuse is death. Illustrated by hogs' tusks.

5. Each part of the human body depends on the other parts—
   The heart depends on the brain.
   The brain depends on the heart.
   The muscles are fed by the blood.
   The blood is cleaned by the lungs.
   &c., &c., &c.

CHAPTER II

The body resembles the steam-engine in most ways, but differs from it in two essentials.

I. The body grows. II. The body repairs itself.

Lobsters re-make lost limbs.
Human bodies do not re-make themselves.
Their power of recovery is limited to repair of ordinary wear-and-tear.

CHAPTER III

A piece of meat or a length of calico can become larger by (1) adding another piece of meat or length of calico to itself.

A pudding can become larger by (1) adding and (2) mixing more rice and milk.

The human body can become larger by (1) adding, (2) mixing, and (3) assimilating into itself some of those things which surround it, *i.e.* **Air, Food, Water**.

CHAPTER IV.—THE SKIN

Epidermis . .	The scarf skin. Contains no blood-vessels.
Malpighian Layer . . .	Cells containing colouring matter.
Dermis . . .	The true skin. Contains blood-vessels and nerves. Is uneven, forming little hillocks called papillæ. Contains fat cells.
Sweat Glands .	Absorb the perspiration out of the blood.
Sweat Ducts .	Pass perspiration out of the pores of the skin.
Pores of Skin .	Openings of sweat ducts.

CHAPTER V.—THE BONES

BONE TISSUE. COMPOSED OF	**Organic (Animal) Matter**	Forms the greater part of babies' bones. Makes one-third of most bones.
	Earthy (Mineral) Matter	Forms the greater part of old people's bones. Makes two thirds of most bones.
	Compact (Dense) Tissue	The hard outside part of bone.
	Spongy (Cancellous) Tissue	The soft and porous portion of a bone. Is lighter than **compact (dense) tissue.** Looks like sponge with little holes in it. Contains a reddish fluid made of fat cells and blood-vessels.

Kinds of Bones.	**Hollow Bones.**	As in the leg. Have an outer coat of **compact (dense) tissue**, a head of **spongy (cancellous) tissue**, and the hollow middle filled with marrow.
	Flat Bones.	As the top of the skull or a shoulder of mutton. Made of a piece of **spongy (cancellous) tissue** lying between two layers of **compact (dense) tissue.**
	Irregular Bones.	As the back-bone. Made of **spongy (cancellous) tissue,** and covered with **compact (dense) tissue.**

CHAPTER VI.—BACK-BONE, OR VERTEBRAL COLUMN

Each Vertebra is Composed of	*a.* The body. *b.* The channel for the spinal cord to go through. *c.* The three wings (or processes).
Number of Vertebræ in the Back-bone.	7 Neck bones (cervical vertebræ). 12 Back-bones (dorsal vertebræ). 5 Loin bones (lumbar vertebræ). 5 Bones joined together (sacrum). 4 Bones imperfectly joined together (coccyx).

CHAPTER VII.—THE BONES OF THE TRUNK

Breast-Bone (Sternum)	The bone going down the front of the body. Is soft, and composed of spongy (cancellous) tissue and cartilage. Is joined to the back-bone (vertebral column) by the ribs.
The Ribs.	Look like hoops of a barrel. Join the breast-bone (sternum) and back-bone (vertebral column) together. Have movable joints, and move as we breathe. There are 24, 12 each side the body. 7 pairs are joined to the breast-bone (sternum). 3 pairs are joined together, and are fastened to the seventh pair. 2 pairs are loose.

CHAPTER VIII.—THE BODY BARREL (PELVIS)

A bony bottomless box, protecting some delicate organs of the body.
Like a bridge, the two legs being the two piers.
Is very strong, bearing the weight of the back-bone.
Distributes the weight of the body.

Composed of—

- I. **Back Wall.** — Part of the **Back-bone** (5 united vertebræ). (**Sacrum**).
- II. **Right Side Wall.** III. **Left Side Wall.** — The 2 **Hip Bones** (**Ilium**) — Flat narrow bones at the top. Thick and broad lower down. Form a cup on each side (*acetabulum*).
- IV. **Front Wall.**
  - **Upper Fourth Side** (**Pubis**). — The Upper and most forward bone of the front wall of the body barrel (pelvis).
  - **Lower Fourth Side** (**Ischium**) — The lower and more backward bone of the front wall of the body barrel or pelvis.

CHAPTER IX.—THE MUSCLES

ALL MUSCLES ARE

Composed of—
Fine threads (fibrillæ).
A number of fine threads (fibrillæ) lying together is a *fibre*.
A bundle of fibres is a *fasciculus*.
A number of fasciculi make a *muscle*.
Each fibre is surrounded by a skin (*sarcolemma*).

When weakened by illness are aided by tonics.
Are like elastic.
Can expand. Can contract. Can remain stationary.
Are all over the body. Nearly 500 in number.
Are of two sorts—

Voluntary, or, act in obedience to our wills.
Involuntary, act without our will.

CHAPTER X.—VOLUNTARY MUSCLES

Do our will. Examples—

I. **Bending (flexor) muscles.**

As inside the hands. As the biceps in the arm.

II. **Extending (extensor) muscles.**

As outside the hands. As the triceps of the arm.

To every bone are attached muscles to enable it to move.
Muscles are generally fastened to bones by means of **Tendons.**

CHAPTER XI.—INVOLUNTARY MUSCLES

Act and move without our will.
Are sometimes like boxes (hollow muscles).
Are like horses without reins (unstriped or non-striated).
Respond to the emotions that we feel.

CHAPTER XII.—THE HEAD

Contains the brain.
Is the seat of most of the senses—the eyes, ears, nose, and tongue.
Divided into two parts—

The Skull (Cranium). **The Face.**

THE SKULL (CRANIUM)

Is the long box made of eight bones, and contains the brain.

The names of the eight bones are—

1. **The Forehead Bone (Frontal).**
   The front of the head.
2. and 3. **The Partition Bones (Parietal).**
   One on each side of the head at the back.
4. **The Occipital Bone.**
   The back of the head. Has a hole in it, through which the spinal cord passes.
5. and 6. **Temples (Temporal Bones).**
   One on each side of the head in front.
7. **The Wedge Bone (Sphenoid).**
   Runs right through the head.
8. **The Sieve-like Bone (Ethmoid).**
   At the side of the head. Full of holes, through which the nerves pass.

CHAPTER XIII.—THE FACE

Has fourteen bones—

7 belonging to the nose. 2 belonging to the cheek.

5 belonging to the mouth.

Nose Bones.

2 Nasal Bones. Forming the bridge of the nose.

2 Twisted Bones (Spongy). Inside the nose, and make long air passage.

2 Tearful Bones (Lachrymal). Like little troughs, and carry the tears from the eyes to the nose.

1 Ploughshare (Vomer Bone). Inside the nose, dividing it into two nostrils.

7

Cheek Bones.

2 Cheek Bones (Malar). Differently shaped in different races.

Mouth Bones.

2 Upper Jaw Bones (Upper Maxillary). Into which the upper teeth are fixed. Immovable.

2 Roof of the Mouth Bones (Palate). Inside the mouth.

1 Lower Jaw Bone (Lower Maxillary). Into which the lower teeth are fixed. Moves up and down, sideways, and round about.

CHAPTER XIV.—THE BRAIN COVERS

There are two brain covers outside the skull.

I. The Hair

Has two little grease (sebaceous) glands to secrete oil at each root. Each hair consists of two parts—

1. *The Root.*
   1. **The root.** 2. **Its covering (follicle).**
   3. **A projection (papillæ),** Which is supplied with blood-vessels, and creates new cells.

2. *The Shaft or Stem* — Is the part we see, subdivided into—
   1. **The pith (cerebral medullary portion).**
   2. **An outer sheath (cortical portion).**

II. The Scalp. Formed of skin, fat glands, and muscles.

There are three brain covers inside the skull.

I. **The Hard Mother (Dura Mater) Covering.**	A tough strong skin, rough where it touches the skull, smooth where it touches the brain.
II. **The Spider Web or Fluid Network (Arachnoid) Covering.**	A delicate skin containing fluid.
III. **The Pious Mother (Pia Mater) Covering.**	Supplies the brain with blood.

CHAPTER XV.—THE BRAIN

Divided into four parts—

The Big Brain (*Cerebrum*).
The Little Brain (*Cerebellum*).
The Oblong Marrow (*Medulla Oblongata*).
The Brain's Bridge (*Pons Varolii*).

THE BIG BRAIN (CEREBRUM)

Lies at the top of the head.
Is divided into two hemispheres.
Is drawn up into folds or convolutions.
Weighs in a man from 45 to 64 ounces.
Weighs in an idiot or an ape under 16 ounces.

CHAPTER XVI.—THE BRAIN

II. **THE LITTLE BRAIN (CEREBELLUM)**	Lies just beneath the great brain. Controls our power of walking, running, and balancing ourselves.
III. **OBLONG MARROW (MEDULLA OBLONGATA)**	Is the enlarged end of the spinal cord, lying at the top of the back-bone. The most important part of the brain.
IV. **THE BRIDGE (PONS VAROLII)**	Connects the two hemispheres of the little brain (*cerebellum*).

CHAPTER XVII.—NERVE FIBRES

Run all over the body. Are of two kinds.

Each nerve fibre is composed of three parts—

1. The central part (axis cylinder). 2. The white substance. 3. The Swann sheath.

A bundle of fibres covered by a skin (*neurilemma*) is a nerve.
There are two kinds of nerve fibre—

1. Carrying-to (*afferent*), takes news to the brain.
2. Carrying-from (*efferent*), takes news from the brain.

Both kinds within one skin (*neurilemma*) is a mixed nerve.
Nerve fibres are generally white.

CHAPTER XVIII.—NERVE CELLS

Are stores of nourishment for the nerve fibres.
Every nerve fibre proceeds from a nerve cell.
The nerve cells may have other more important uses, but we do not know for certain.
Nerve cells are grey.

CHAPTERS XIX. AND XX.—THE SPINAL CORD

Is the continuation of the narrow oblong brain (*medulla oblongata*).
Is 18 inches long. Is enclosed in the back-bone.
Is composed of—

Nerve Fibres.—Carriers of news.
Nerve Cells.—Feeders. Each nerve as it enters the cord has two roots.

Back Roots (*posterior*) { Carry messages *to* the brain.
Carry news of sensation.

Front Roots (*anterior*) { Carry messages *from* the brain.
Carry commands about movement.

Each pair of roots unite and form a spinal nerve trunk.

CHAPTER XXI.—REFLEX ACTION

Is action without our will or consciousness, as choking.

CHAPTER XXII.—THE SYMPATHETIC SYSTEM

Consists of a chain or knot of nerves lying each side of the backbone.
Is connected to spinal cord by—
The carrying-to (*sensory afferent*) nerves.
The carrying-from (*motor efferent*) nerves.
Is connected with — The Circulation. The Digestion. The Respiration.

CHAPTERS XXIII. AND XXIV.—THE TONGUE

Composed of muscles. Covered with mucous membrane.

MUCOUS MEMBRANE.	Smooth under the tongue. Raised into hillocks or papillæ on the upper part.

PAPILLÆ	**Thread or Filiform.**	Small, thread-like, and pointed. Most numerous at tip of the tongue. Possess the power of tasting sweet and salt things.
	Mushroom or Fungiform.	Larger, and of a mushroom shape. Are red in appearance.
	Rampart or Circumvallate.	Largest, and surrounded by a wall or rampart. Limited in number, 7 to 10. Placed at the back of the tongue, taste what is bitter. Are placed in the shape of the letter V.

CHAPTER XXV.—THE GLANDS

Organs that extract materials from the blood.
There are many sorts. Two of the principal ones are—

1. The preparing glands (secreting).
2. The separating glands (excreting).

THE PREPARING GLANDS (SECRETING)	Take certain materials from the blood, make it into material, and store it for use in the body.
THE SEPARATING GLANDS (EXCRETING)	Take certain materials from the blood, which they evict from the body.

SPITTLE MAKING GLANDS (SALIVARY)

Are preparing glands (secreting).
Keep the mouth moist. Aid digestion of food.
1. The parotid, near the ear.
2. The submaxillary, under the jaw.
3. The sublingual, under the tongue.

Parotid. *Near the Ear.* — Are the largest.

Sub-maxillary. *Under the Jaw.* — Have opening ducts under the tongue.

Sublingual. *Under the Tongue.* Can easily be seen.

Saliva. — Has three uses—
1. Makes the food wet.
2. Makes the food stick together.
3. Turns the starch of the food into sugar.

MUCOUS MEMBRANE. — Fine soft skin, lining all the parts of the body that have to do with the food. Always wet with a fluid made by the glands.

CHAPTER XXVI.—THE TEETH

Milk teeth, 20. Have no roots, and drop out at the age of five.
Permanent teeth, 28. Wisdom teeth, 4.

PARTS OF A TOOTH — 1. The root or fang. 2. The neck. 3. The crown.

STRUCTURE OF A TOOTH.
Dentine. Forms the greater part of a tooth. Soft, and soon decays if exposed to air.
Enamel. Hard, brittle, and white. Has no blood-vessels.
Pulp cavity. Filled with a mass of nerves and blood-vessels.

CHAPTER XXVII.—THE TEETH

The BITERS or INCISORS. — The eight front teeth—four in the upper, four in the lower jaw. Use—to bite, gnaw, or cut.

The DOG TEETH or CANINE. — Four teeth, one either side of the incisors—two in the upper, two in the lower jaw. Use—to tear.

The CHEWERS or BICUSPID (two ridges). — Eight teeth—two either side of the canine, four in the upper, four in the lower jaw. Use—to chew.

The GRINDERS or MOLARS. — The eight back teeth (or twelve when the wisdom teeth have grown). Use—to grind.

CHAPTER XXVIII.—THE JOURNEY OF THE FOOD

THE UVULA.—The soft or flexible end of the palate.

THE PHARYNX. — A chamber, into which there are five openings from (1) the nose, (2) the ears, (3) the lungs, (4) the mouth, and (5) the stomach.

GULLET, or THE ŒSOPHAGUS.
- A tube connecting the pharynx with the stomach.
- Use—a channel by which the food passes into the stomach.
- **COATS OF THE ŒSOPHAGUS**
  - **The outer or muscular**, composed of involuntary muscle fibres. Use—to push the food downwards.
  - **The middle or connective.** Use—to connect the other two coats, and yet to prevent their touching each other.
  - **The inner or mucous**, composed of glands secreting mucus.
  - Use—to keep the food wet.

THE ALIMENTARY CANAL. — The long pipe which the food passes through in the process of digestion.

CHAPTER XXIX.—THE STOMACH

STOMACH DOOR OR CARDIAC ORIFICE. — The opening of the gullet into the stomach.

COATS OF THE STOMACH.	**The Outer Coat (Muscular).**	Very thick. Consists of three sets of involuntary muscles. Use—to keep the food moving.
	The Middle Coat (Connective).	Lies between the inner and outer coats. Use—to connect and divide them.
	The Inner Coat (Mucous).	Composed of gastric or peptic glands. Use—to secrete and pour out the gastric juice.
	The Over-all Coat (Peritoneum).	The fourth coat. Use—to secrete the serum.

GASTRIC JUICE.	Ten to twenty pints poured into the stomach daily. Composed to a large extent of water. Uses—dissolves food, especially nitrogenous ; has some effect on fat foods ; changes food into chyme.
CHYME.	The food after it has been acted on by the various juices of the stomach.

CHAPTERS XXX. AND XXXI.—THE DUODENUM—THE SWEETBREAD

THE GATEWAY (*Pylorus*),	A door in the stomach through which the food or chyme passes. Opens and shuts like a mouth. Only opens when food (chyme) pushes against it.
A TIGHT BAND (*Sphincter*),	The muscle which keeps the gate (*pylorus*) shut.
12-INCH PIPE (*Duodenum*),	A narrow tunnel into which the gate (*pylorus*) opens. Four pipes join together and open into it—one from the sweetbread or pancreas, two from the liver, one from the gall-bladder. Has three coats which, like those of the stomach, tumble and moisten the food.
THE SWEETBREAD (*Pancreas*),	A gland 7 inches long, and broader one end than the other. A pale pink colour. Use—to secrete a fluid or juice which is poured into the 12-inch pipe or duodenum.
PANCREATIC DUCT,	A little tube connecting the sweetbread (*pancreas*) and the 12-inch pipe (*duodenum*). Use—to conduct the pancreatic juice from one to the other.
PANCREATIC JUICE,	Juice secreted by the sweetbread or pancreas. Use—to complete work begun by the salivary and gastric glands.

CHAPTER XXXII.—THE INTESTINES

A long pipe into which the food passes. There are two parts—
The small intestine. The large intestine.

Small Intestine.
- A long tube about $\frac{3}{4}$-inch thick and 20 feet long.
- Twisted up, and occupying small space—constantly moving.
- Has four coats—
  - *The Over-all coat (peritoneum).*—Contains the serum-secreting glands.
  - *The Outer or Muscular coat.*—Has two kinds of muscles, not three.
  - *The Middle or Connective coat.*—Divides while connecting the other two.
  - *The Inner or Mucous coat.*—Full of glands secreting a fluid called the intestinal juice.
- Provides a large surface for absorption.

INTESTINAL JUICE.
- The fluid secreted by the inner or mucous coat.
- Use—to finish any work not completed in the mouth, stomach, or 12-inch pipe or duodenum.

THE JOURNEY OF THE FOOD.
- Taken out of duodenum. Brought into intestines.
- Churned in small intestine. Mixed with intestinal juice.

CHAPTER XXXIII.—THE LIVER

A large organ divided into two parts, the right side being bigger than the left.

A gland which secretes one pint and three-quarters daily of bile, as well as doing other things. Always at work. Has four gateways—Two leading to—Two leading from the liver.

1. **The Gate Vein** (*Portal Vein*)
   - Carries the rich blood from the stomach, the sweetbread (*pancreas*), the spleen, and the intestines into the liver.
2. **The Liver Artery** (*Hepatic*)
   - Carries clean blood from the heart to enliven and re-create the liver.
3. **The Liver Vein** (*Hepatic*)
   - Carries both sorts of the blood out of the liver when it has done its work.
   - Pours it into the inferior vena cava.
4. **The Liver Duct** carries not blood but bile.

A Lobule
- Is the little workshop inside the liver, where the rich blood goes to be changed.
- Use—to deprive the blood of certain materials which it stores and uses.

THE GALL-BLADDER.
- A little bag under the liver.
- Receives the bile secreted by the liver.
- Use—to store the bile and pour it into the duodenum when wanted.

BILE—Mixes with the chyme in the duodenum.

CHAPTER XXXIV.—THE ABSORBENT SYSTEM

SHAGGY HAIR (Villi).
- Four million little projections, mixed up with the secreting glands and lying close together. Use—to take up the chyme.
- **Milk Tubes (Lacteals).**
  - A small white tube, one or two in the centre of each shaggy hair.
  - Use—to absorb the chyle.
  - Have blood-vessels in among them.

JOURNEY OF FOOD.
- From the intestine into the milk thread (*lacteal*) of the shaggy hair (*villus*).
- From the shaggy hair (*villus*) into the lymphatic vessels;

  or
- From the intestines into the little blood-vessels.

CHAPTER XXXV.—LYMPH AND THE LYMPHATIC VESSELS

LYMPH is the fluid part of the blood after it has fed the muscles and other parts of the body from which it comes, and taken up their waste material.

A **LYMPHATIC VESSEL** is a tube with bags (valves) inside it which prevent the lymph from going the wrong way. The chief force which drives the lymph forwards is muscular action.

LYMPHATIC GLANDS are structures that act as filters.

CHAPTER XXXVI.—THE SPLEEN.—THE COLON

THE MILT (*Spleen*). — A small organ weighing half a lb. Purple in colour. As big as a closed fist. Spongy in texture. Shaped as in drawing. Use—Influences the blood.

The large intestine. About six feet long and two inches thick. Has many blood-vessels. Has some delicate nerves.

Nerves of Colon
- Are irritated when touched by waste substance of foods.
- Set in motion some muscles which eject the waste.

CHAPTER XXXVII.—FOOD AND DRINK

Body-warming or carbonaceous foods—
Give to the body warmth and strength.

Flesh-forming or nitrogenous foods—
Give to the body material by which to grow and repair itself.

Blood-purifying or mineral foods—
Keep the blood pure, the nerves strong, the bones hard.

OXYGEN and HYDROGEN are both elements, and are indivisible.

WATER
- Composed of oxygen, 8 lbs. in every 9 lbs.
- Composed of hydrogen, 1 lb. in every 9 lbs.
- Composes 16 ounces out of every 22 ounces weight of the human body.
- A man requires to drink 3 to 3½ pints daily.

Beer does not give strength. Spirits do not keep the cold out.

CHAPTER XXXVIII.—THE JOURNEY OF THE AIR

BY THE NOSE — Where it is filtered and warmed, passes into the Pharynx, which has five doorways—

INTO THE THROAT CHAMBER OR PHARYNX.
1. From the mouth.
2. From the ear (Eustachian tube).
3. From the nose (nasal passage).
4. To the lungs (*larynx*). 5. To the stomach.

The air goes from the throat chamber (*pharynx*) into the windpipe (*trachea*).

WINDPIPE
- Has little door at the top called Epiglottis.
- *Epiglottis.*
  - Very sensitive, closing if touched.
  - Use—to keep food out of the windpipe.

CHAPTER XXXIX.—THE JOURNEY OF THE AIR

ENTERS
1. By the nose. 2. By the pharynx. 3. Past epiglottis.
4. Through glottis. 5. By the larynx. 6. Into the windpipe.

THE WINDPIPE (*Trachea*)
- Runs down middle of the chest. Is ¾ in. wide, 4½ in. long.
- Front and sides composed of muscular bands. The back soft.
- The top is called the glottis.
- Second ring, or cricoid cartilage, entirely encircles it, and causes pain if pieces too large are swallowed.
- Divides into two pipes called bronchial tubes (*bronchi*).

BRONCHIAL TUBES (*Bronchi*)
- Take the air into the lungs.
- Subdivide into smaller tubes until they become fortieth part of an inch wide.
- Each tiny tube ends in an air cell.

CHAPTER XL.—THE LUNGS

The right lung has three divisions to be filled with air.
The left lung has two divisions to be filled with air.
Look like trees because of their tiny branching tubes.
Look like sponges. The air cells waiting empty for the air.
Some of the air is left in the cells.
Some comes out changed by its work in the lungs.

AIR WHEN IT GOES INTO THE BODY.	**Composed of**	Oxygen . . .	21 parts
		Nitrogen . . .	79 ,,
			100
AIR WHEN IT COMES OUT OF THE BODY.	**Composed of**	Oxygen . . .	16 parts
		Nitrogen . . .	79 ,,
		Carbonic acid . .	5 ,,
			100

USE OF AIR. To make the blood fit to sustain life.

BREATHING
- Is a muscular action.
- Makes the spaces in the lungs alternately larger and smaller.
- Is carried out by—
  1. The Intercostal Muscles.
  2. The Diaphragm.

CHAPTER XLI.—THE JOURNEY OF THE BLOOD

BLOOD.
- A hot red fluid.
- Is chiefly water, mineral salts, &c. &c.
- Clots when exposed to the air.
- Forms one-tenth of the weight of a healthy body.
- Composed of corpuscles floating in a fluid called

THE BLOOD FLUID (*Liquor Sanguinis*) Is the fluid in which the corpuscles float.

THE WHITE CORPUSCLES
- Are slightly larger than the red ones.
- Change in shape.
- Use—unknown.

RED CORPUSCLES
- Are round in form like draught men.
- Very tiny—140,000 only standing as high as an inch.
- 500 times as numerous as the white corpuscles.
- Use—to carry the oxygen from the air into the body.

CHAPTER XLII.—THE JOURNEY OF THE BLOOD

THE HEART	Is the size of our fist. Contains four chambers— Two on the right side. Two on the left side. Each top chamber has a door leading to the lower chamber. *Auricles.*—The two top chambers. *Ventricles.*—The two bottom chambers. *Right Auricle.*—Fills with blood—twelve tablespoonfuls. *Right Ventricle.*—Receives the blood from right auricle.
THREE FLAP VALVE OR TRICUSPID VALVE	Opens and lies flat to let blood into the ventricle. Floats on the top of the blood when ventricle is full and thus prevents more blood entering. Attached by little cords to the walls of the heart.
THE BLOOD	Passes through both auricle and ventricle every three-quarters of a second.
THE LUNG AND PULMONARY ARTERIES	Receive the blood from the right ventricle.

CHAPTER XLIII.—THE JOURNEY OF THE BLOOD

AN ARTERY	Is a thick strong pipe; has 3 coats— Outer coat—strong and rough. Middle coat—composed of muscles, and is elastic. Inside coat—elastic, and lined with soft skin. Subdivides again and again till becomes capillaries.
CAPILLARIES	Are all over the body. Are very tiny. Have very thin walls. Blood flows slowly through them.
THE LUNG ARTERY	Divides into two smaller arteries— One going to left lung. One going to right lung.
PULMONARY ARTERY.	These also divide and subdivide until they become capillaries.
LUNG CAPILLARIES	Are in among the air-cells, and everywhere else. Use—to carry oxygen into and carbonic acid out of the blood.
COURSE OF THE BLOOD.	Flows from the right ventricle into the lung artery. Goes back to the heart by veins.
RATE OF THE BLOOD.	Travels fast in the arteries. Travels slowest in the capillaries. Travels quicker in the veins.

CHAPTER XLIV.—THE JOURNEY OF THE BLOOD

VEINS.

- The vessels into which the capillaries carry the blood.
- Have three coats—
  1. Outer coat. 2. Middle coat. 3. Lining coat.
- Have pockets or valves to prevent the blood running backwards.

LUNG OR PULMONARY VEINS.

- There are four—
  - Two from one lung,
  - Two from the other.
- Unite into two pipes only.

THE TWO FLAP-VALVE (*Bicuspid*)

- Has only two flaps.
- Is also called the Mitral Valve.

COURSE OF THE BLOOD.

- From the capillaries to the veins.
- From the many veins into five.
- From five veins into two.
- Into the top left room (*left auricle*) of the heart.
- From the left auricle through the trap-door (*mitral valve*).
- Into the left ventricle.

CHAPTER XLV.—THE JOURNEY OF THE BLOOD

COURSE OF THE BLOOD THROUGH ARTERIES, CAPILLARIES, VEINS, BACK TO HEART.

- **Aorta**
  - Large artery about one inch across.
  - Branches at the neck—
    - One branch goes to the right.
    - One branch goes to the left.
    - Two branches go to the head.
  - The main body goes on down the body.
  - Gets smaller and has more branches.
  - Carries blood all over the body.
  - Forms two big arteries at the bottom of the back.
    - One goes to the right leg.
    - One goes to the left leg.
- Arteries end in capillaries, which carry blood into veins.
- Veins grow larger as they unite till they reach the
  - **Large Upper Vein** (*Superior Vena Cava*) — Carries the blood back into the right auricle of the heart.

CHAPTER XLVI.—THE JOURNEY OF THE BLOOD

PORTAL CIRCULATION.
- *Portal Vein.*—Carries the rich blood into the liver.
- *Liver.*—Changes the rich substances, and purifies the blood.
- *Liver Vein* (*Hepatic*).—Carries the changed blood to the inferior vena cava.
- The large lower vein.
- *Inferior Vena Cava.*—Carries the blood into the heart.
- *Pulse.*—Corresponds to the beating of the heart.

CHAPTERS XLVII. AND XLVIII.—THE HANDS, ARMS, SHOULDERS

They contain sixty-four bones; thirty-two on each side of the body.

COLLAR BONE (*Clavicle*)
- Is joined to the top of the breast-bone (*sternum*) and to the shoulder bone (*scapula*).
- Its duty is to keep the shoulders extended.

SHOULDER BONE (*Scapula*)
- Is shaped like a triangle.
- Is flat and thin, becoming thicker at the third angle.
- Joins the collar bone.

UPPER ARM BONE (*Humerus*)
- Is long and strong.
- Has one body and two heads. One head at the top, one at the lower end.
- The top head fits into the cup made by the shoulder bone.
- The lower head fits on to two bones.

THE SPOKE BONE (*Radius*)
- Is one of the two bones on which the lower head of the upper arm bone fits.
- Resembles the spoke of a wheel. Has two heads.
- The top head has a small shallow cup into which rests the lower head of the upper arm bone.
- The lower head is fastened to the bones in the wrist.

THE ELBOW BONE (*Ulna*).
- Is the second bone on which the lower head of the upper arm bone fits. Has one head.
- Fits into the upper arm bone by a hinge.
- It cannot bend backward.

THE WRIST BONES (*Carpal*).
- There are eight wrist bones, two rows of four.
- Are joined to the elbow and spoke bones.
- Are bound together by ligaments.

BINDERS OR LIGAMENTS
- Are strong white fibrous bands.
- Bind the bones together.
- Are elastic and allow the bones to move.
- Protect the joints from external injury.

THE PALM BONES (*Metacarpal*).
- There are five.
- Are the beginning of the fingers and thumbs.
- Bound together by skin and flesh.

THE FINGER BONES (*Phalanges*). There are three in each finger and two in the thumb.

CHAPTERS XLIX. AND L.—THE LEGS AND FEET

The bones of the legs and feet resemble those of the arms and hands.

THE THIGH BONE (*Femur*)
- Is like the pier of an arch, and bears the whole weight of the body. Is the largest and heaviest bone in the body.
- Reaches from the thigh to the knee.
- Has a cup-and-ball joint.
- Cannot move so easily as the arm-bone, being bound by strong restrictive ligaments.
- The two thigh-bones start about a foot apart, but meet at the knee.

THE SHIN BONE (*Tibia*)
- Is placed near the skin.
- Is joined to the ankle at one end, to the thigh-bone (*femur*) at the other.

THE BUCKLE BONE (*Fibula*)
- Is smaller, and lies behind the shin bone.
- Is fastened top and bottom to the shin bone.

THE KNEE-CAP (*Patella*)
- Is a small bone placed over the joint of the thigh (*femur*) and shin (*tibia*) bones, where they join.
- Is slightly curved in shape, and should not be pressed.
- Use—to protect the joint and prevent the knee bending backwards.

THE ANKLE BONES (*Tarsal*).
- There are seven.
- One is fastened to the shin bone (*tibia*).
- The largest forms the heel.

THE INSTEP BONES (*Metatarsal*).
- There are five.
- Are the beginning of the toe bones.

THE TOE BONES (*Phalanges*).—There are fourteen in the five toes.

The bones of the feet form an arch.

Use—to prevent the body being jolted at every step.

CHAPTER LI.—THE JOURNEY OF A SENSATION

FEELING CELLS (*Pacinian Bodies*)
- Are little oval bodies among the nerve fibres of the hillocks (*papillæ*) in the true skin (*dermis*).
- Are sensitive to touch.
- Each one has a messenger nerve attached to it, which carries the news of feeling to the brain.

TOUCH CORPUSCLES (*Tactile Corpuscles*)
- Are closer together where we feel most, as on the lips, tips of fingers, tongue, and palms of the hands.
- Are fewer on the back and the thigh, where feeling is less intense.
- Have different powers.
- Those feeling heat most quickly outside the body are in the cheek, eyelid, and elbow; inside the body, in the gullet and stomach.

CHAPTER LII.—THE NOSE

Contains two nose bones (*nasal*).
Contains three scroll-like bones (*turbinated bones*).
One ploughshare bone (*vomer*).
Two tearful bones (*lachrymal*).

FRONT DOORS (*Nostrils*).
- Two passages to admit the air.
- Lined with small hairs which exclude intruders.
- Lead into air passage and olfactory chamber.

BACK DOORS (*Posterior Nares*).
- There are two. Lead from air passage into throat chamber (*pharynx*).

SMELL CHAMBER (*Olfactory*).
- Small chamber, the base of which is made by the middle scroll-like bone (*middle turbinated*).
- Contains nerve with exceedingly fine nerve ends.
- Lined with skin (*mucous membrane*).

THE SMELL NERVE (*Olfactory*).
- The nerve that conveys the sensation of smell to the brain.
- Enters the brain by sieve-like bone (*ethmoid*).

Examples given.
- It is possible to miss a smell, to sniff a smell, to swallow a smell.

THE JOURNEY OF AN ODOUR
- Through the nostril. Up the air passage.
- Into the smell chamber (*olfactory*). By the smell nerve.
- Through the sieve bone (*ethmoid*). Into the brain.

A smell is the consciousness in the brain that certain things have touched a certain part of the body.

CHAPTER LIII.—THE VOICE

VOICE BOX (*Larynx*). Is the enlarged top of the windpipe.

THE SHIELD RING CARTILAGE (*Thyroid*)
- Is the top ring of windpipe (*trachea*).
- Is soft or pliable behind.
- Is hard and angular in front; there it forms Adam's apple.
- Attached to the letter U bone (*hyoid*).

SECOND RING CARTILAGE (*Cricoid*)
- Is second ring of windpipe (*trachea*).
- Is hard, firm, and goes all round.
- Attached to the shield ring cartilage (*thyroid*).

ARYTENOID CARTILAGES
- Are the two cartilages between the shield ring (*thyroid*) and the second ring (*cricoid*) of the windpipe.
- They do whatever the second ring (*cricoid*) does.
- Are sharp like rocks, and like pyramids in shape.
- Are attached to the shield ring (*thyroid*) by the vocal cords.

THE VOCAL CORDS
- Are two bands of elastic fibre stretched between the two arytenoids behind, and the thyroid in front.
- If tight, they vibrate when touched by the air, producing sound.
- When loose, the air passes through them, causing no sound.
- They move in various ways.

CHAPTER LIV.—THE JOURNEY OF A SOUND

THE EAR—Has three parts—

1. Outer. 2. Middle. 3. Inner.

OUTER EAR.
- The part we see consists of two parts—
  1. The wing (*pinna*). 2. Hearing passage (*auditory canal*).
- **Auditory Canal.**—About $1\frac{1}{2}$ inches long. Lined with fine hairs.
- **Fine Hairs.**—Keep dust out of ear. Push out the wax.
- **Wax.**—Made by glands. Protects drum (*tympanic membrane*).
- **Drum of the Ear.**
  - A thin muscular skin.
  - Stretched tightly across hearing passage (auditory passage), and acts as wall between outer and middle ear.

MIDDLE EAR.

- Chamber which receives sound from drum (*tympanic membrane*).
- **Ear Pipe or Eustachian Tube.**
  - Passage from middle ear to the throat chamber (*pharynx*).
  - Carries warm air from mouth to the middle ear.

Course of Sound.—Enters wing (*pinna*). Goes down auditory canal. Through wax. Reaches drum.

CHAPTER LV.—THE JOURNEY OF A SOUND

THE MIDDLE EAR.

- **Bones of the Ear.**
  - The hammer (*malleus*). The anvil (*incus*). The stirrup (*stapes*).
  - Hammer (*malleus*)
    - Lies close to the drum (*tympanic membrane*).
    - Use—to vibrate with drum.
  - Anvil (*incus*)
    - Lies close against the hammer.
    - Use—to vibrate with hammer.
  - Stirrup (*stapes*)
    - Lies close to anvil.
    - Use—to vibrate with anvil.

THE INNER EAR.

- Has three parts—
  1. The Shell tube (*cochlea*).
  2. The Ribbon loops (*semicircular canals*).
  3. The Entrance room (*vestibule*).
- **Clear Water** (*perilymph*)
  - Clear water filling all three parts, in which floats tiny skin bag (*membranous labyrinth*).
- **The Skin Maze** (*membranous labyrinth*)
  - Contains water and ear stones (*otoliths*).

Course of Sound—Touches drum. Vibrates hammer. Vibrates anvil. Vibrates stirrup.

CHAPTER LVI.—THE JOURNEY OF A SOUND

THE INNER EAR.

- **The Entrance Room** (*vestibule*).
  - Chamber into which sounds penetrate.
  - Use—to collect and distribute sounds.
- **Shell Tube** (*cochlea*)
  - Is in the form of a curl.
  - Composed of fine, hard, delicate bone.
  - Contains water (*perilymph*).
  - Contains skin maze bag (*membranous labyrinth*).
- **The Ribbon Loops** (*semicircular canals*)
  - Have three loops and five openings.
  - Are composed of fine hard delicate bone.
  - Contain water (*perilymph*).
- **Skin Maze Bag** (*membranous labyrinth*)
  - Is full of water.
  - Has little hammers on the skin.
  - Is far too complicated to describe.
- **Course of Sound**—From stirrup to vestibule. To shell. To nerves. To brain.

CHAPTERS LVII. AND LVIII.—THE JOURNEY OF LIGHT

THE EYE PROTECTORS.
- The eyebrows. The eyelashes.
- The eyelids. The joining wet skin (*conjunctiva*).

THE EYEBALL
- Is the organ of sight. Is round.
- Part of it we see, *i.e.* the white coloured disc and the pupil.
- Is embedded in a bone socket. Rests on a cushion of fat.
- Is washed by tears. Is moved by muscles.

LACHRYMAL GLANDS. Glands that secrete tears.

LACHRYMAL CANALS. Channels that carry off tears from the eyeball.

LACHRYMAL DUCTS. Channels that carry off tears from the canals.

EYE MUSCLES (Six in all).
- Four straight (*recti*); move eyeball—up, down, in, out.
- Two slanting (*oblique*); move eyeball—down and out, up and out.

CHAPTER LIX.—THE JOURNEY OF LIGHT

Has three coats.

THE EYEBALL.

The Outer Coat.

1. THE HARD COAT (*sclerotic*)
   - Covers the back and sides of the eyeball.
   - Is very strong.
   - Is white and opaque.
2. THE HORNY COAT (*cornea*)
   - Covers the front of the eyeball.
   - Is quite clear and transparent.
   - Is strong. Has no blood-vessels.

The Middle Coat.

1. THE COLOURED COAT (*choroid*)
   - Covers the back of the eyeball.
   - Consists of a network of blood-vessels.
   - Contains colour cells.
2. THE HAIRY COATS (*ciliary processes*)
   - Cover the two sides of the eyeball.
   - Are the end of the coloured coat (*choroid*).
   - Are the beginning of the curtain (*iris*).
3. THE WATER CHAMBER (*aqueous humour*)
   - A chamber containing several drops of water lying behind the horny coat (*cornea*).
4. THE CURTAIN (*iris*)
   - Gives its distinctive colour to the eye.
   - Has muscles that influence the pupil.
5. THE ROUND WINDOW (*pupil*)
   - Is the centre of the iris. Admits light waves. Contracts or expands to accommodate them.

CHAPTER LX.—THE JOURNEY OF LIGHT

THE INNER COAT.	**The Network Coat** (*Retina*)	Is very fine. Goes all round the back of the eyeball. Lines the coloured coat (*choroid*). Receives the rays of light.
	The Crystal Glass (*Crystalline Lens*)	Receives rays of light and conveys them to the retina. Looks like an oval crystal bead. Is about the third of an inch in size. Lies immediately behind the iris. Is held in its place by bands.
	The Tunic (*Capsule*).	The covering of the crystalline lens, to which is fastened the ciliary muscles.
THE EYEBALL.	**The Glassy Water** (*Vitreous Humour*)	Is very soft. A kind of jelly. Is transparent. The largest portion of the eye.
	Seeing Nerve (*Optic Nerve*).	The nerve which takes impressions from the retina, and conveys them to the brain.

THE END

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